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POTENTIAL ENVIRONMENTAL IMPACTS
OF
ENERGY FACILITIES AND OTHER DEVELOPMENT
ON
FISH HOUSE COVE
DELAWARE RIVER, CAMDEN COUNTY, NEW JERSEY

FINAL REPORT

JUNE 1980

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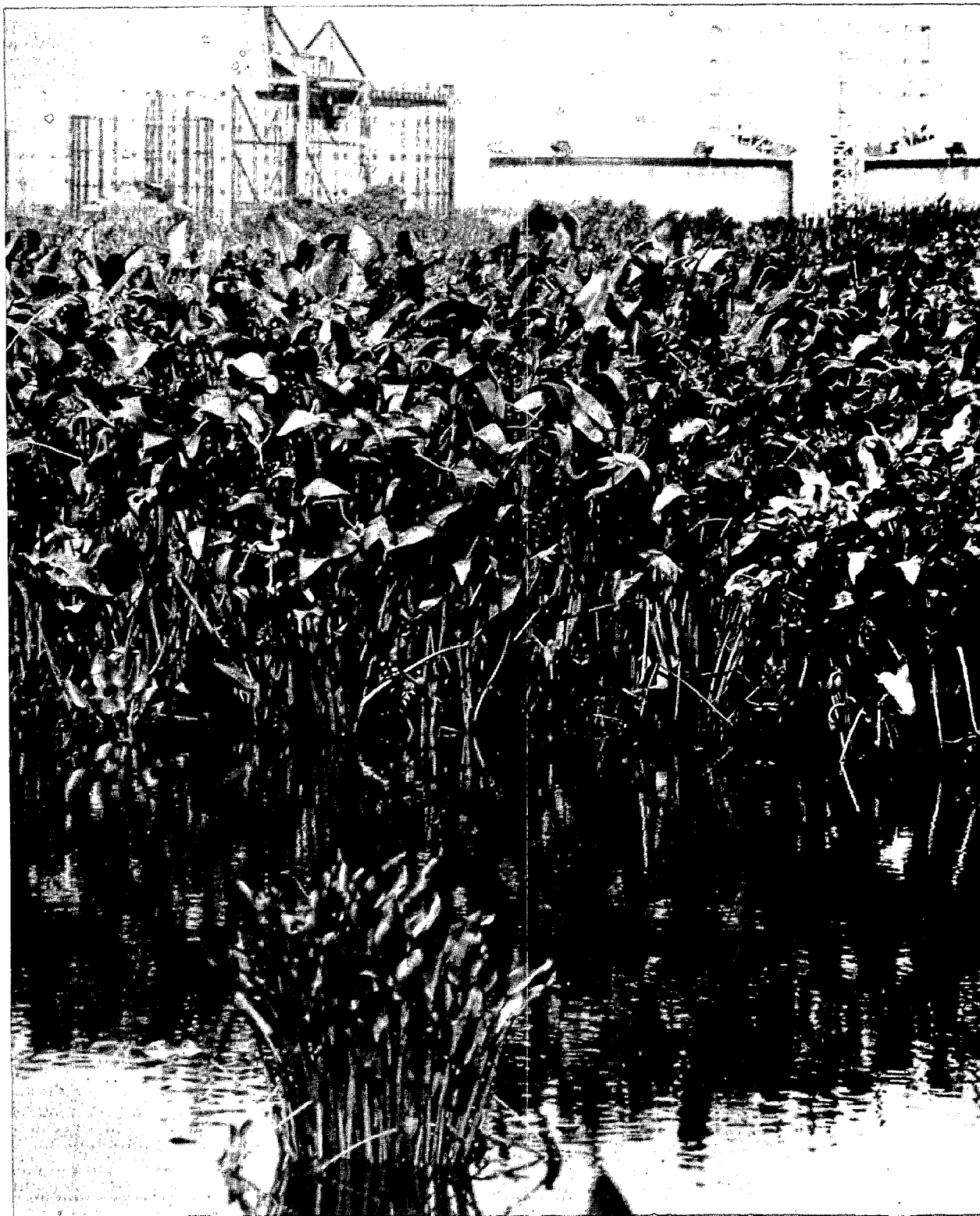
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Frontispiece. The freshwater tidal marsh at the Fish House Cove, Delaware River, Camden County, New Jersey, September 1979. Common arrowhead forms the stand in the center. A small clump of pickerelweed is in the foreground. The view is northeastward toward the Texaco oil storage facility.

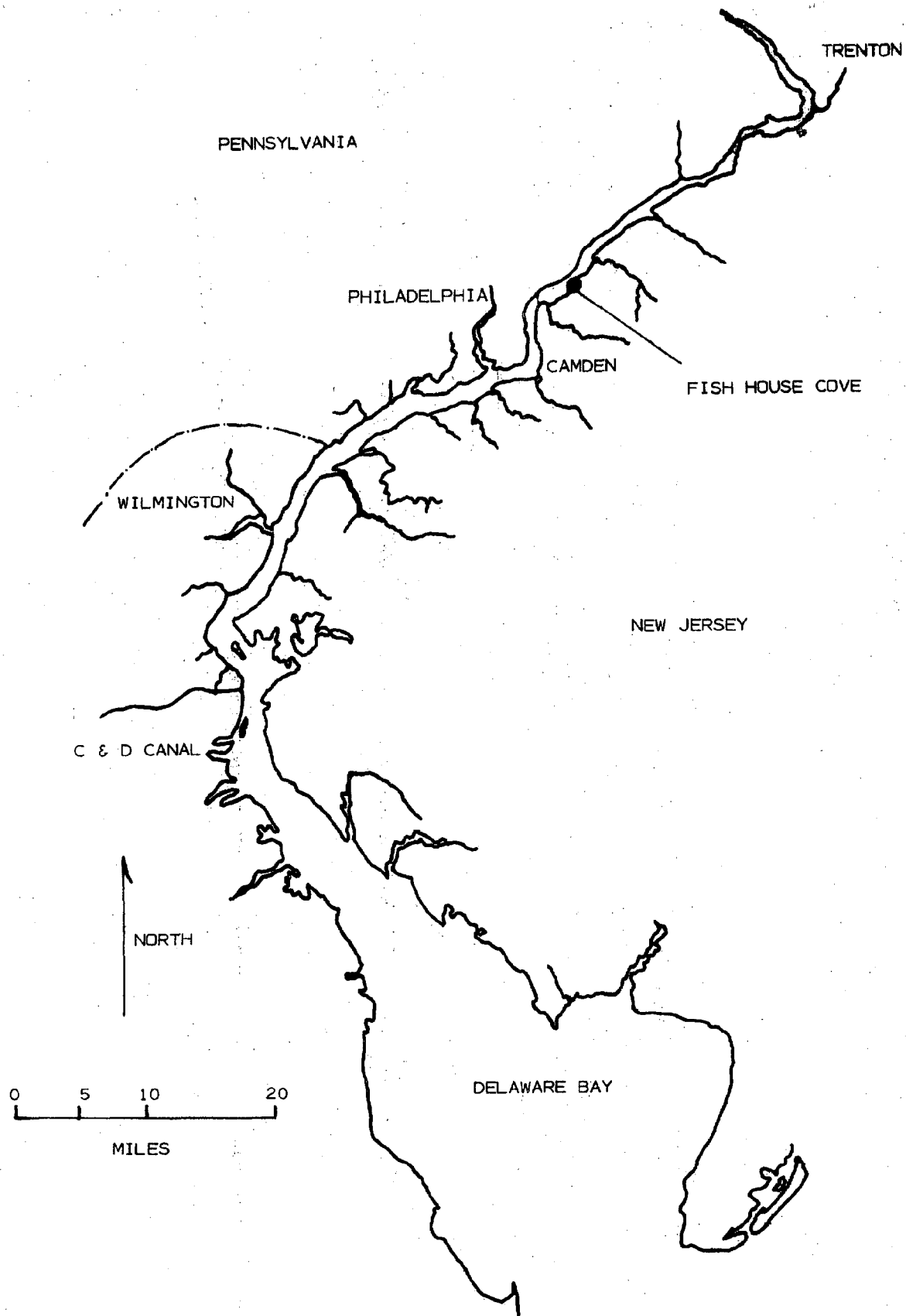


Figure 18. Fish House Cove in the lower Delaware River Basin.



Figure 2. Aerial Photo Fish House Cove, Pennsauken, Camden County, New Jersey. 17 March 1979

EXECUTIVE SUMMARY

In 1957, the US Fish and Wildlife Service (USFWS) recommended the public acquisition of Fish House Cove. Since 1957, approximately 75% of the marshes and mudflats of the Delaware River estuary have been eliminated by man's actions. Fish House Cove is possibly the highest quality existing remnant of the marshes inventoried and ranked by USFWS during the 1950's.

The entire vegetated and unvegetated wetland area at Fish House Cove should be considered a critical area because freshwater riverine tidal marsh has become scarce in the Delaware River Valley due to the deposition of dredged spoil and the establishment of landfills on such areas. Fish House Cove is the largest and possibly the most diverse remaining tract of freshwater riverine tidal marsh in surrounding New Jersey counties.

From a biological standpoint, the floristic diversity of the Fish House Cove marsh signals high value, both as a current habitat for wildlife and as an example of species and of vegetation types that were historically common in marshes that bordered the Delaware River in this region. Fish House Cove is a significant area for wildlife, especially birds. Since 1972, 229 species of the 261 species of birds estimated to occur in the County have been observed at the Cove. Numerous endangered, threatened, and declining species of birds have been observed at Fish House Cove, and the Cove is also a known habitat for rare plants.

The Delaware River water quality in the vicinity of the Cove is seriously affected by low dissolved oxygen levels, high fecal coliform levels, residual chlorine, and numerous organic chemicals. The Philadelphia Northeast Water Pollution Control Plant is situated almost directly across from the Cove on the Pennsylvania side of the River. The discharge from this plant has a significant effect on water quality near and in the Cove. The effluent from the nearby Pennsauken Township and Camden Sewerage Treatment Plants and from the Cities Service, Texaco, and Amerada Hess oil transfer terminals can also be expected to impact the Cove. Because the Cove represents a delicate ecosystem, all nearby operational and construction activities can affect it negatively and should be closely and constantly scrutinized pursuant to existing State and Federal laws protective of the environment.

RECOMMENDATIONS

The consultant's principal recommendations for the preservation of the high quality coastal ecosystem at Fish House Cove are focused directly on the preservation of the existing wetland ecosystem. They call for increased efforts by State and Federal agencies to implement and enforce existing regulatory authorities to assure protection of the Cove until the Cove can be preserved and enhanced under public ownership. CCEA must serve as a catalyst to insure that State and Federal agency attention is and continues to be focused on Fish House Cove as a coastal resource of local, State, and National significance. CCEA can and should take all of the steps recommended here to provide both negative prohibitions on potential adverse impacts and positive actions to preserve and enhance the ecosystem at Fish House Cove.

1. The Camden County Environmental Agency formally should transmit a copy of the current vegetation map of Fish House Cove (Figure 1) to the District Engineer, Philadelphia District, Army Corps of Engineers. The Corps should be requested to recognize all of the mapped wetlands as lands subject to regulation, for the disposal of dredged or other fill material, pursuant to Section 404 of the Clean Water Act. CCEA should monitor activities that affect the marsh, and should insist upon (1) Corps enforcement of the Refuse Act (Section 13 of the River and Harbor Act) and other Federal prohibitions on the illegal discharge of material into the Cove, and (2) thorough Corps review of any applications for Section 10 River and Harbor Act (for construction in the waterway) or Section 404 Clean Water Act (for placement of fill) authorizations that might affect the Cove, in accordance with the National Environmental Policy Act of 1969.

2. The CCEA formally should request the Commissioner of the New Jersey Department of Environmental Protection (NJDEP) to update, revise, and promulgate State wetlands maps of Fish House Cove, so that the area can be regulated as coastal wetlands under the Wetlands Act of 1970. The State legislation is far more comprehensive as a regulatory measure than Federal jurisdiction under Section 404. NJDEP has delayed promulgation of the two map sheets that cover parts of the Cove, together with 40 other wetlands photomaps elsewhere in southern New Jersey, for more than six years. If the NJ-DEP continues to avoid timely promulgation of the maps, as a last resort the CCEA or others should institute a court suit to compel implementation of the Wetlands Act pursuant to the New Jersey Environmental Rights Act of 1974.

3. The Delaware River Basin Commission (DRBC) should be requested formally by CCEA to give special scrutiny to any proposal that requires docket approval under Section 3.8 or Section 11 of the Compact of 1961 and that might affect the ecosystem of Fish House Cove adversely. CCEA should transmit a copy of the current vegetation map of Fish House Cove (Figure 1) to the DRBC to facilitate its review pursuant to the Resolution 78-1 policy on wetlands preservation (effective 28 June 1978). DRBC review may provide a backup layer of protection in addition to that offered by other State and

Federal authority, and CCEA should see that full advantage of the potential for DRBC review is taken.

4. CCEA should petition NJDEP Division of Water Resources and USEPA Region II to make certain that NPDES permit conditions are enforced for all current and proposed dischargers in the vicinity of Fish House Cove. During 1978 the Division proposed procedures and a schedule of penalties for violations of water quality permit conditions (for NJAC 7:14-8.1 et seq.; Docket No. DEP-051-78-11). CCEA should take steps to receive and review copies of monitoring data for permit compliance routinely, and to make certain that NJ-DEP is collecting appropriate penalties for permit violations.

5. In the event that any fill has been placed without permit in the wetlands or former wetlands of Fish House Cove since implementation of the Federal Water Pollution Control Act Amendments of 1972 (now the Clean Water Act), the CCEA should petition the District Engineer of the Corps to issue a cease, desist, and restore order to require removal of the fill and reestablishment of the marsh. Ample legal precedent and authority exist for such action (for example, US vs. Keewan, S.D.Fl., 1974; US vs. Sexton Cove Estates, S.D.Fl., 1975). Ample aerial photography of the region including Fish House Cove exists for a precise determination of whether illegal filling has taken place, but such an analysis was beyond the mandate of the present report. Qualified wetland specialists should oversee any restoration of marsh vegetation.

6. CCEA should work with the Delaware Valley Regional Planning Commission (the designated Section 208 Clean Water Act planning agency) and other agencies to eliminate sources of non-point pollution that may affect Fish House Cove adversely. Such sources include the eroding piles of fill adjacent to the southern boundary of the Cove and the presumably illegal waterside dump, southwest of the nearby Camden Wastewater Treatment Plant, less than 0.2 mile from the Cove.

7. CCEA should seek the assistance and cooperation of the NJDEP Bureau of Coastal Enforcement and Field Services in ongoing surveillance and monitoring of the Cove. Additional assistance for surveillance may be sought from Coastwatch Program volunteers through the network sponsored by the American Littoral Society headquartered at Sandy Hook, New Jersey.

8. CCEA should ascertain the status of riparian ownership of the lands within and adjacent to Fish House Cove and the status of State waterfront development permits authorizing existing and proposed development. Such permits have been required since 1914 for improvements or developments undertaken individually or "as a part of a general plan which involves the construction or alteration of a dock, wharf, pier, bulkhead, bridge, pipeline, cable, or any other similar or dissimilar water-front development" by any person or municipality (NJSA 12:5-3). CCEA should make certain that the Bureau of Coastal Project Review in the Division of Coastal Resources, NJDEP, considers fully the resource values at Fish House Cove when it evaluates any waterfront development permit that may affect the Cove.

9. CCEA should formally request funds from the Coastal Zone Management Program administered by the Bureau of Coastal Planning and Development, Division of Coastal Resources, NJ DEP, and/or from other sources to conduct a four-season detailed study by skilled taxonomic botanists at Fish House Cove to ascertain whether plants formerly collected from the Cove actually persist at the Cove. Additional funds should be sought for a thorough study by qualified personnel of Cove sediments and of the current and potential impacts from discharges of wastewater to the Delaware River on the Cove ecosystem.

10. The CCEA formally should nominate Fish House Cove for designation by NJDEP as a natural area in the State Natural Areas System established pursuant to NJSA 13:8-20 et seq. in accordance with NJAC 7:2-11 et seq. This step would provide no direct State regulatory control over Fish House Cove. It would, however, provide a formal State recognition of the quality and significance of the Cove ecosystem. NJ DEP then would be more likely than at present to take advantage of the Federal State consistency requirements under the Coastal Zone Management Program to insure that no direct or indirect Federal actions (including permit actions) will have an unacceptable adverse impact on the Cove. If Fish House Cove is privately owned, the Cove could become the first privately owned natural area recognized under the State legislation.

11. CCEA should petition the Bureau of Coastal Planning and Development in the Division of Coastal Resources and the Green Acres and Recreational Opportunities Program, NJDEP, to provide technical assistance to CCEA in preparing grant requests for State and Federal funds that may be used to transfer any privately owned sections of the Cove into public ownership, using eminent domain if necessary. Steps should be taken to plan for public use of the Cove compatible with marsh preservation.

12. CCEA should request the assistance of the mass media (newspapers, radio, and television) to publicize the extraordinary quality and scarcity of the Fish House Cove resource and should enlist the editorial support of the media to generate public enthusiasm for special protection of the Cove through public ownership and care. The assistance of conservation groups such as the New Jersey Conservation Foundation, The American Littoral Society, the Izaak Walton League, Ducks Unlimited, the Sierra Club, and the New Jersey Audubon Society should be requested in this effort. Careful attention should be given to the choice of an appropriate management agency and to formulation of a management plan that will protect and enhance Cove resources.

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John Munro, vegetation and photography; Charles Rhodehamel and William Ressler, comments on terrestrial and aquatic animals; Robert Ford, collection and analysis of water samples; Valdis Jurka, oil discharge calculations; Stephen Kullen, map preparation under the supervision of William Bale; Susan Beal, typist; Dr. James Schmid, technical and editorial supervision and summary recommendations.

Additional contributors were:

John Olson, Environmental Planner, Camden County Environmental Agency, wildlife section; Kenneth Tischner, naturalist, field data on local wildlife populations; Carolyn O'Donnel, Camden County Environmental Agency, mechanical report preparation; Joan Batory, Camden County Environmental Agency, editor and production supervisor for final report.

Dr. Ernest Schuyler, Academy of Natural Sciences of Philadelphia, provided taxonomic expertise in identifying uncommon plants. Dr. David Atkin, New Jersey Department of Energy, provided comments on a draft of the report.

Table 1. Common names and scientific equivalents of plant names mentioned in the text. Scientific nomenclature is that of Fernald (1970).

Herbaceous Plants

Common Name	Scientific Name
Arrow-arum	<i>Peltandra virginica</i>
Arrowhead, bur	<i>Sagittaria rigida</i>
Arrowhead, common	<i>Sagittaria latifolia</i>
Arrowhead, slender	<i>Sagittaria eatoni</i>
Bindweed	<i>Convolvulus arvensis</i>
Bulrush, great	<i>Scirpus validus</i>
Bulrush, river	<i>Scirpus fluviatilis</i>
Bur-marigold	<i>Bidens laevis</i>
Cattail, broadleaf	<i>Typha latifolia</i>
Cattail, narrowleaf	<i>Typha angustifolia</i>
Clearstem	<i>Pilea pumila</i>
Cucumber, wild	<i>Cucurbita</i> sp.
Dodder	<i>Cuscuta</i> sp.
Elodea, common	<i>Elodea canadensis</i>
Fern, sensitive	<i>Onoclea sensibilis</i>
Flag, blue	<i>Iris versicolor</i>
Flag, sweet	<i>Acorus calamus</i>
Hempweed, climbing	<i>Mikania scandens</i>
Jewelweed	<i>Impatiens capensis</i>
Loosestrife, spiked	<i>Lythrum salicaria</i>
Naiad	<i>Najas flexilis</i>
Pickernelweed	<i>Pontederia cordata</i>
Pipewort, Parker's	<i>Eriocaulon parkeri</i>
Pondweed	<i>Potamogeton</i> sp.
Purslane, water	<i>Ludwigia palustris</i>
Reed, common	<i>Phragmites communis</i>
Smartweed, water	<i>Polygonum punctatum</i>
Spatterdock	<i>Nuphar advena</i>
Spike-rush	<i>Eleocharis</i> sp.
Tearthumb, halberdleaf	<i>Polygonum arifolium</i>
Threesquare, common	<i>Scirpus americanus</i>
Waterhemp	<i>Acnida cannabina</i>
Wildrice	<i>Zizania aquatica</i>

Woody Plants

Ash sp.	<i>Fraxinus</i> sp.
Boxelder	<i>Acer negundo</i>
Buttonbush	<i>Cephalanthus occidentalis</i>
Indigo, false	<i>Amorpha fruticosa</i>
Sycamore	<i>Platanus occidentalis</i>
Willow, black	<i>Salix nigra</i>
Willow, red	<i>Cornus amomum</i>

I. VEGETATION AND OTHER COVER TYPES

The vegetation of the remnant tidal freshwater marsh at Fish House Cove exemplifies a formerly much more extensive vegetation type on the Delaware River. Such marshes were common on both sides of the River in this region before there was extensive agriculture, urbanization, or industry. Subsequently a deep ship channel was constructed to Trenton, and much of the waterfront land in and near Camden and Philadelphia was intensively developed. When major channel dredging of the Delaware River was intensified during the 1940's, many freshwater riverine tidal marshes were replaced by spoil banks. Now only about one quarter of the original riverbank marsh remains in the region (Tyrawski 1979).

The Fish House Cove marsh itself has been much reduced from its extent earlier in the present century. Pressure for development continues to rise on the upriver and downriver sides of the Cove, and the chances of its disturbance through the direct or secondary effects of development are substantial. The Cove as defined in this report occupies 197.6 acres (Figure 1). The riverine boundary of the Cove was established by drawing a line between the 36th Street Bridge to Petty Island and the tip of the spit that extends west from the Texaco oil storage facility. The landward boundary of the Cove for this report is the landward boundary of the adjacent wetlands. This boundary differs substantially from the boundary of wetlands mapped for regulatory purposes by NJDEP (Figure 2), as discussed subsequently.

The marsh plant communities at the Cove are exceptionally diverse in the regional context, and they can be described as being in excellent condition. The plants exhibit vigorous growth and little evidence of insect or disease infestation. The only apparent encroachment from development presently consists of continuing siltation from fill eroded by runoff and by the tides from the Vineland Construction Co. property to the south and southwest of the Cove. The silt provides favorable habitat for common reed stands that could expand into the other marsh vegetation types.

Field observations were made at the Cove on 13 September 1979. The water in the marsh at Cove is relatively clear, and sediment movement into the Cove generally appeared not to be great at the time of observation. Bottom substrate in all observed areas appears to be stable. The edges of vegetated areas that border on open water support stands of several submerged aquatic plant species (common elodea, green algae, and pondweed). The presence of numerous small fish, snails, waterfowl, other marsh birds, muskrat, snapping turtles, and one crayfish, combined with the healthy appearance, vigorous growth, and great diversity of marsh plant species, characterizes Fish House Cove as an area with excellent marsh vegetation and with excellent aquatic habitat in the marsh.

The inland edge of the wetlands is lined with varying amounts of rafted debris (trash and wood), but the remainder of the open marsh is relatively free of such rubbish. Only a few small areas along the inland edge have accumulated so much debris that they lack vegetation. Typically such floating or semi-floating materials shift their locations with each flood or storm tide. The accumulated wood apparently is not causing deleterious effects to the marsh.

Table 2. Extent of wetland vegetation and land cover types at Fish House Cove, Delaware River, Camden County, New Jersey. Data are from planimeter measurements of the original map shown as Figure 1, based on photographs taken 17 March 1979. Percentage totals do not add precisely as a result of rounding.

WETLAND CATEGORY	ACREAGE	% OF MARSH	% OF COVE
Marsh	74.0	100	37
Wildrice	10.4	14	(5)
Spatterdock	4.5	6	(2)
Cattail	3.0	4	(2)
Common reed	10.7	14	(5)
Lower	13.4	18	(7)
Middle	21.0	28	(11)
Upper	11.0	15	(6)
Forest	1.5		1
Mudflat	39.7		20
Beach	0.3		0
Open Water	<u>82.1</u>		<u>42</u>
Total	197.6		100

VEGETATION TYPES DURING 1979

On the basis of the field inspection and the interpretation of stereoscopic, true color, vertical, aerial photographs (scale, 1:12,000) taken on 17 March 1979, twelve vegetation and land cover types were identified at Fish House Cove. Seven of the types represent freshwater herbaceous marsh (74.0 acres). One type is a forested wetland (1.5 acres). The remaining land cover types are beach (0.3 acres), mudflat (39.7 acres), open water (82.1 acres), and undifferentiated upland (not planimetered; Figure 1). Here marsh vegetation will be discussed first. Mixed types will be presented following the comments on floristically pure stands. Then the forested wetland will be described, and finally, the unvegetated wetland types. Uplands are outside Fish House Cove as defined herein, and they are noted only briefly.

The nomenclature of species mentioned is presented in Table 1. Acreage of types is summarized in Table 2. The landward boundary of the Cove was determined on the basis of stereoscopic interpretation of photographs and the delineation of wetland vegetation.

Wetland Vegetation

In this section the four single-species stands of tidal marsh are discussed first. Next, the three mixed marsh types are presented. Then the wetland willow forest is described. Beach, mudflat, and open water wetland types were described in the preceding paragraph. The single-species stands are readily recognizable as discrete vegetation types. The mixed marsh types are much more subjective characterizations of species associations in which individual clones or patches of single species are too small to delineate separately on the map at a scale of 1:4,800. The mixed type delineations were based on professional judgments during photointerpretation and were observed in the field to exhibit a reasonable correlation with visible conditions of vegetation and topography.

Monospecific Stands

Wildrice occupies about 14% of the Fish House Cove marsh. The single stand is in the easternmost part of the Cove near the Penn Central (Amtrak) Railroad. This stand is the largest in Camden County and is floristically almost pure. There are a few arrowhead plants intermixed with the wildrice. The stalks were 11 feet tall or more at the time of late summer field observation (Figure 3). Many of the stems had lodged (Figure 4). Small patches or single stalks of wildrice may be found scattered throughout the marsh outside the pure stand that is delineated in Figure 1. The wildrice stand encompasses 10.4 acres (5% of the total Cove acreage). Wildrice is an annual grass that reproduces by seed each year.

Spatterdock occupies a linear patch oriented northwest-southeast in the central section of the Cove (Figure 5). Arrow-arum is the only species that mixes with spatterdock in this patch. Spatterdock also is a component of the lower mixed marsh type. Spatterdock occupies 4.5 acres (2% of the Cove and 6% of the marsh).

Two stands of cattail are present in the northeastern section of the marsh (Figure 6). Narrowleaf cattail is the predominant species. There are minor admixtures of broadleaf cattail and bindweed. The cattail stands account for 3.0 acres (2% of the Cove and 4% of the marsh).

Common reed stands occupy several parts of the Cove. Where they are present at the Cove, the common reed stands are generally monospecific. As elsewhere in mid-Atlantic tidal marshes, common reed appears to crowd out and to compete successfully with other species following human disturbance (Figure 7). Scattered bindweeds are entwined around the common reed stalks in the tidal marsh. The five tidal common reed stands occupy 5% of the Cove (10.7 acres) and 14% of the marsh. Common reed is also present on areas near Fish House Cove that are no longer flowed by the tides (uplands). Such stands are not delineated in Figure 1. Common reed is a plant with broad habitat tolerance, and differences in surface elevation or associated species generally must be used to distinguish marsh stands from upland stands that are not wetlands.

Lower Marsh

Five areas of lower mixed marsh are adjacent to the mudflats. The individual plants are more widely spaced than in the other marsh types closer to the upland. In this vegetation type the plants generally occur as distinct clumps, clusters, or clones. They are less intermixed and tangled than the species of the other mixes. Threesquare, pickerelweed, and spatterdock are the predominant species present; spike rush, great bulrush, common arrowhead, bur arrowhead, and slender arrowhead are less frequent associates (Figures 8, 9, and 10). The submerged common elodea and naiad are conspicuous both in the open water areas adjacent to the emergent species and in pond-like open spaces amid the emergent species (Figure 11). Those areas of the Cove that immediately face the back channel of the Delaware River are edged by a 10 foot wide or wider strip of common threesquare (Figure 12). The lower mixed marsh occupies 7% of the Cove (13.4 acres) and 18% of the marsh.

Middle Marsh

This vegetation type is dominated by arrowheads, water smartweed, waterhemp, pickerelweed, and bur marigold (Figures 12, 14, and 15). Less common, but well dispersed throughout the two stands, are arrow-arum, jewelweed, and wildrice. The appearance of this type was homogenous in late summer, at least in part because of the relative uniformity of height and the prominent, climbing water smartweed vines. The 21.0 acres of middle mixed marsh constitute 11% of the Cove and 28% of the marsh.

Upper Marsh

The marsh vegetation type that shows the greatest floristic diversity is the upper mixed marsh along the inland margin of the Cove. Elevational differences account largely for the diversity of the species present in this type. To a ground-level observer this type displays wide contrasts of height and appearance among patches of each species present. In this type

no species can be considered to be predominant. Species present include spiked loosestrife, arrowheads, clearestem, water purslane, arrow-arum, sweetflag, sensitive fern, halberdleaf tearthumb, river bulrush, buttonbush, and red willow. Overall, about 6% of the Cove (11.0 acres) and 15% of the marsh consist of the upper mixed marsh type.

Willow Lowland Forest

Black willow is the predominant tree species at Fish House Cove (Figures 4 and 6). Ash, boxelder, and sycamore are present on the higher edges of the willow stands. The three patches of willow forest occupy 1.5 acres (1% of the Cove).

Uplands

The area outside the marsh and wetland forest stands near Fish House Cove is all considered upland. In the adjacent section of Pennsauken there is a large percentage of suburban, urban, and industrial land uses, with a few fringes of forest that can be considered native forest remnants. The area immediately surrounding Fish House Cove reflects all of these conditions. The upland was not planimetered, and no upland is reported in the acreage for Fish House Cove. There is a pond to the east of the railroad that may be tidally connected with the Cove through culverts. The pond vicinity was not investigated for this report.

PREVIOUS INVESTIGATIONS

No comprehensive literature review was possible within the budgetary constraints of this report. Materials available to the consultant in-house and those provided by the Camden County Environmental Agency and by the Philadelphia District, Army Corps of Engineers, were reviewed for their relevance to the concerns of the present report. Information of greatest significance is summarized here.

The United States Fish and Wildlife Service (USFWS 1957) inventoried fish and wildlife resources along the Delaware River from Camden to Trenton in relation to the channel dredging in progress at the time. The marsh at Fish House Cove was one of five marshes recommended at minimum for Federal acquisition and protection because of their high value for waterfowl. Of the approximately 32 marshes and mudflat areas surveyed by USFWS during the mid-1950's, only nine presently remain unfilled. These nine marsh areas represent about 25% of the riverine marsh areas that existed between Camden and Trenton in 1950. The drastic reduction in Delaware River marsh and waterfowl habitat over the past quarter century greatly increases the relative importance of the Fish House Cove marsh in the riverine ecosystem. The riverine marsh at Fish House Cove is possibly the most representative and highest quality remnant of the previously extensive freshwater tidal marshes in New Jersey along the Delaware River as reported and ranked by USFWS (1954).

Since 1957 the section of Fish House Cove marsh that remains unfilled has changed from an area characterized as mostly mudflat to an area with

marsh vegetation covering 65% of the area exposed at low tide. The USFWS (1954) mapped all wetlands in New Jersey that were considered to be of great importance to waterfowl. At that time Fish House Cove ranked with all of the riverine marshes within 10 miles upstream and 20 miles downstream on the Delaware River as a "high value" area on a four-category scale ranging from "high" to "negligible".

The USFWS (1965) evaluated loss of wetlands in New Jersey due to eight development-related types of excavation or filling. During the ten-year period 1954-1964, some 24,609 acres of wetland considered significant by USFWS were destroyed in New Jersey representing 9.6% of the total marshland extant during 1954. The losses were most severe among the tidal freshwater marshes of the Delaware River. The rate of loss is believed to have slowed considerably since 1965. (In large part the decelerated loss of wetlands was a consequence of implementation of the New Jersey Wetlands Act of 1970 and the Federal Water Pollution Control Act Amendments of 1972 [now the Clean Water Act]).

The value of the marsh as habitat for black duck and other waterfowl continues to be high. US Fish and Wildlife Service personnel visited the site during mid-1979 and observed the persistence of the high quality wetlands described in previous USFWS reports (By telephone, Mr. Thomas Hups, USFWS, Absecon NJ, 5 October 1979).

During the autumn of 1972 a part of the Fish House Cove marsh was photographed for the New Jersey Department of Environmental Protection (NJDEP) during the inventory mandated by the Wetlands Act of 1970. Wetland delineations were accomplished by a contractor during 1973. The two NJDEP photomaps for the vicinity (413-1878 and 413-1884) have not yet been promulgated, and hence they lack regulatory effect. Both are inaccurate in the delineation of the 1979 upper inland boundary of the tidal marsh, and they probably do not depict conditions as of 1972 precisely, either. In all cases, too little wetland area was included rather than too much.

Not all of the marsh at Fish House Cove was mapped by NJDEP. The tidal marsh extends south of both photomaps, but no additional wetlands maps apparently were intended to be prepared for this area. The oversight in wetlands mapping has not been rectified by NJDEP since 1972/73.

As show in Figure 2, four floristic types of marsh were mapped by NJDEP. The vegetation as mapped from aerial photographs and field inspections during 1979 for this report differs substantially from the types delineated by the NJDEP contractor. Two explanations separately or jointly account for the differences in the two maps. First, the composition of the vegetation may have changed considerably since 1972. As noted previously, it certainly has changed substantially since the mid-1950's. Second, the 1973 species delineations of the contractor may have been erroneous. A review of the 1972 photography retained by NJDEP at Trenton was beyond the scope of the present investigation. The authors of the present report have found both of the named sources of discrepancy to be operative at numerous sites in coastal New Jersey. Wetland vegetation is a dynamic resource.

FIGURE 1
VEGETATION OF FISH HOUSE COVE,
CAMDEN COUNTY, NEW JERSEY,
SEPTEMBER 1979

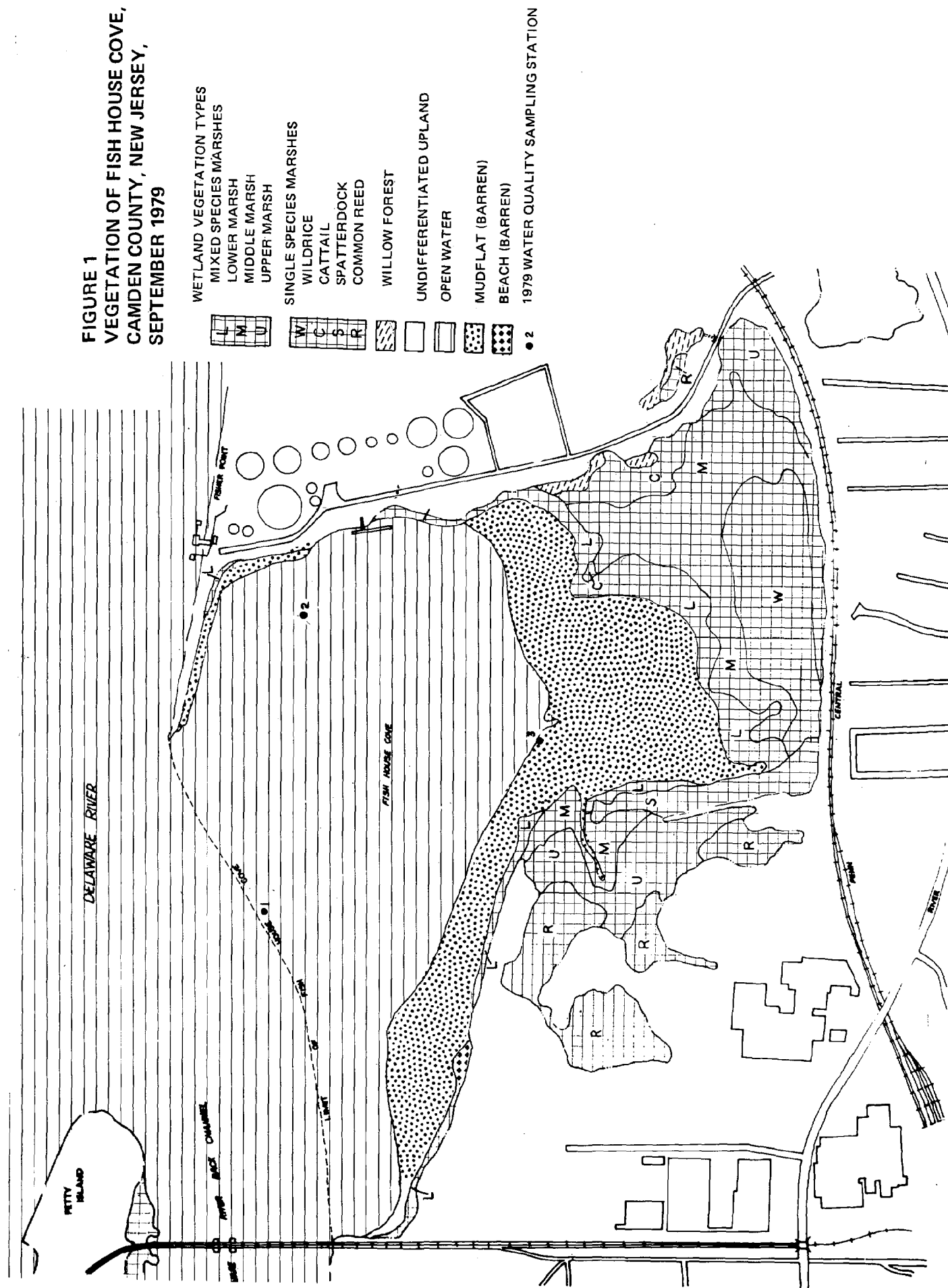


FIGURE 4
POTENTIAL COASTAL WETLANDS

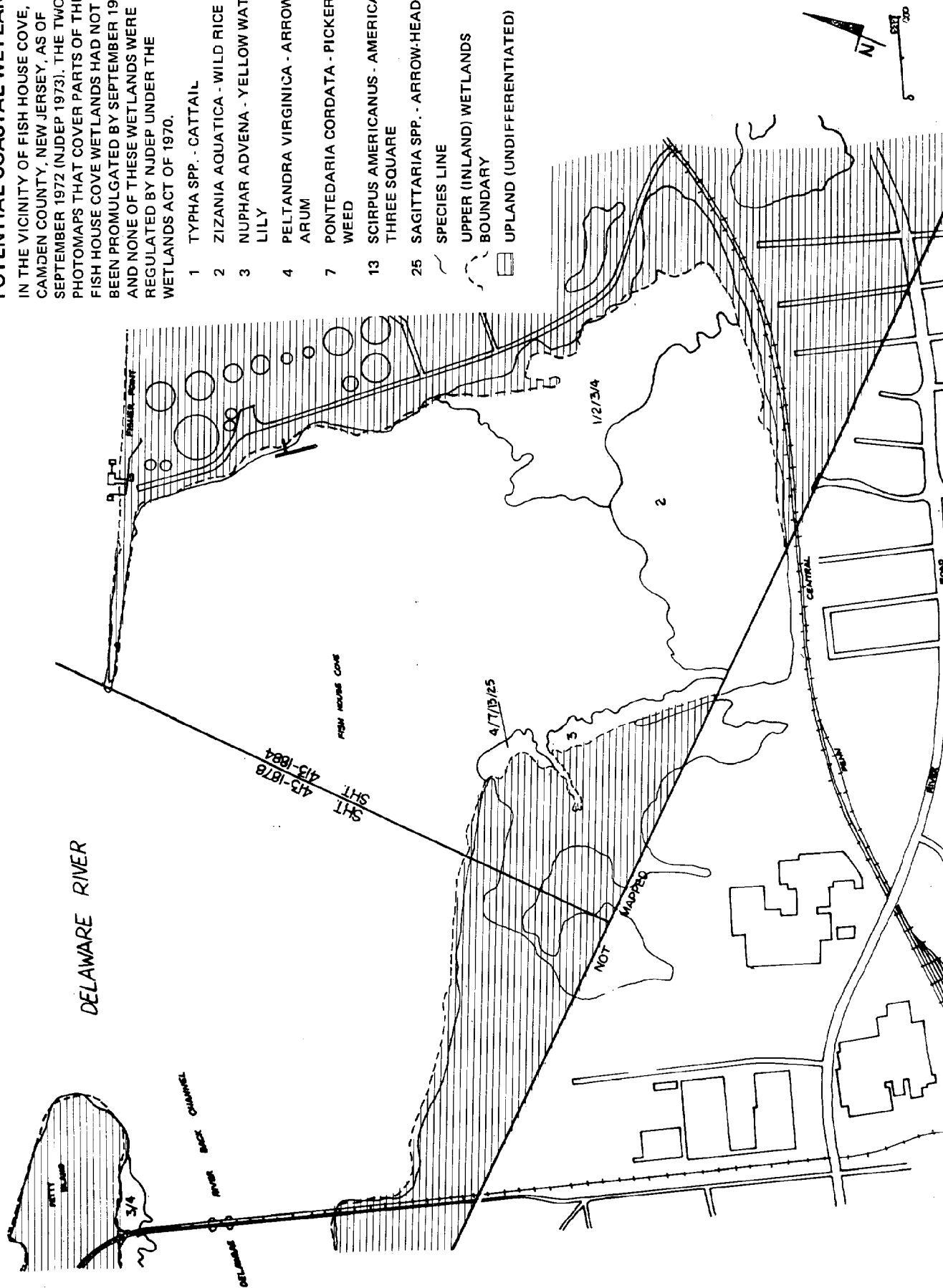
IN THE VICINITY OF FISH HOUSE COVE, CAMDEN COUNTY, NEW JERSEY, AS OF SEPTEMBER 1972 (NJDEP 1973). THE TWO PHOTOMAPS THAT COVER PARTS OF THE FISH HOUSE COVE WETLANDS HAD NOT BEEN PROMULGATED BY SEPTEMBER 1979, AND NONE OF THESE WETLANDS WERE REGULATED BY NJDEP UNDER THE WETLANDS ACT OF 1970.

- 1 TYPHA SPP. - CATTAIL
- 2 ZIZANIA AQUATICA - WILD RICE
- 3 NUPHAR ADVENA - YELLOW WATER LILY
- 4 PELTANDRA VIRGINICA - ARROW ARUM
- 7 PONTEDARIA CORDATA - PICKEREL WEED
- 13 SCIRPUS AMERICANUS - AMERICAN THREE SQUARE
- 25 SAGITTARIA SPP. - ARROW-HEAD

SPECIES LINE

UPPER (INLAND) WETLANDS BOUNDARY

UPLAND (UNDIFFERENTIATED)



Until the Fish House Cove area is remapped by NJDEP, not all of the existing tidal wetlands could be regulated by the State under the Wetlands Act of 1970. Even the mapped area, as of September 1979, however, was unprotected by the State because of non-promulgation of the photomaps. These two photomaps are among the 42 completed sheets yet to be promulgated by NJDEP (WAPORA 1979b).

In an environmental impact analysis for a "land reclamation" project on land at Fish House Cove owned by the Vineland Construction Company, vegetation types were mapped by John G. Reutter Associates (JGRA 1976). Stands of both cattail and common reed (the latter is present today along an unnamed tidal gut mentioned in that report) were indicated as present inland from the State upper inland wetland boundary line. JGRA (1976) did not discuss the obvious discrepancy between the NJDEP mapping of the upper (inland) wetland regulatory boundary and the actual extent of the marsh. The unpromulgated NJDEP wetlands maps were referenced as source material, however, and the southwestern section of the Cove, which was never mapped by NJDEP, was mapped by JGRA (1976) as tidal wetland.

On the basis of a brief field inspection during September 1976, Ferren (1976) opined that the populations of wildrice and river bulrush at Fish House Cove are the largest for each species in Camden County (Ferren 1976). Based on his five years of study of Delaware River intertidal marshes, Ferren (1976) stated that four species uncommon in New Jersey (Bidens bidentoides, Cyperus brevifolius, Sagittaria graminea [the S. eatoni of Fernald], and Sagittaria rigida) are represented now in Camden County only at Fish House Cove, where the latter two species were observed to be common. Three plant taxa not recorded or collected in Camden County for sixty to seventy years are represented in the Local Herbarium at the Academy of Natural Sciences of Philadelphia: Sagittaria subulata (Fish House Cove, 1910), Gratiola aurea var. obtusa (Fish House Cove, 1918; type specimen), and Eriocaulon parkeri (Fish House Cove, 1907). It is possible that these plants still exist at Fish House Cove. Other rare plants long ago were collected from the marsh at Delair, about 1.5 miles upriver from Fish House Cove just north of the modern Betsy Ross Bridge: Scirpus smithii (1907), Eleocharis diandra (1907), and Micranthemum micranthemoides (1910). The latter species is believed now to be extinct. The marshes now confined to Fish House Cove formerly extended continuously upriver past Delair, and intensive scrutiny of the Fish House Cove marsh could lead to a rediscovery of one or more of these rare plants (Ferren 1976). Seventeen additional species not mentioned in Table 1 were reported by Ferren (1976) from Fish House Cove (Table 3).

In the list of specially significant species of plants in Camden County, Jack McCormick & Associates, Inc. (1974) noted that Parker's pipewort was recorded for Fish House Cove. This species inhabits tidal mud banks along the Delaware River in the vicinity of the Cove, as indicated by herbarium specimens in the Academy of Natural Sciences of Philadelphia. It also was noted to inhabit the Cove by Stone in his 1911 flora of the Pine Barrens.

POTENTIAL ENVIRONMENTAL STRESSES ON THE MARSH

Freshwater tidal marshes are much less tolerant of changes in the physical and chemical nature of their environment than are brackish or salt marshes. Freshwater marshes in general are subject to less severe natural

Table 3. Other plant species reported from the vicinity of Fish House Cove, Delaware River, Camden County, New Jersey. These species were reported on the basis of field observations by Ferren (1976). They are not mentioned in Table 1. Nomenclature is that of Ferren.

COMMON NAME	SCIENTIFIC NAME
Beggartick	<i>Bidens frondosa</i>
Blackcherry	<i>Prunus serotina</i>
Groundnut	<i>Apios americana</i>
Hibiscus	<i>Hibiscus moscheutos</i>
Ironweed	<i>Vernonia noveboracensis</i>
Maple, silver	<i>Acer saccharinum</i>
Mulberry, red	<i>Morus rubra</i>
Needlegrass	<i>Aristida</i> sp.
Paulownia	<i>Paulownia tomentosa</i>
Pimpernel, false	<i>Lindernia dubia</i>
Sandbur	<i>Cenchrus</i> sp.
Sedge	<i>Cyperus brevifolioides</i>
Sedge	<i>Cyperus odoratus</i>
Sedge	<i>Cyperus rivularis</i>
Spikerush	<i>Eleocharis smallii</i>
Switchgrass	<i>Panicum virgatum</i>
Waterweed	<i>Elodea nuttallii</i>

flux in various habitat parameters than brackish and saline marshes. Changes in turbidity, sedimentation rate, or salinity, and changes due to oil or other hydrocarbon spillage can produce great damage or deterioration in a freshwater marsh.

Turbidity and Sedimentation

A minor increase in turbidity probably would have little immediate effect upon the wetland vegetation at Fish House Cove. Only long-term exposure to moderate or severe turbidity and the sedimentation that accompanies such turbidity would have a pronounced effect on the wetland vegetation. The submerged aquatic vegetation of the Cove becomes exposed or nearly exposed at low tide and is covered at high tide by 2 to 5 feet of water. Hence, only relatively high turbidity levels for extended time periods would be likely to block the sunlight essential for submerged plant growth. Turbidity may have subtle effects on emergent vegetation. A decline in vigor could be quantified by comparison of standing crop measurements over a period of years. The size, general dimensions, and consequent biological productivity of submerged aquatic plants and small emergent wetland plants ordinarily becomes reduced in a proportional relationship to the degree of turbidity increase (Darnell 1976).

Sedimentation from adjacent landfills or development could have a detrimental effect upon tidal marsh vegetation. Seeds of annual marsh plants are dormant during the autumn, winter, and early spring. Burial by too much sediment may prevent seedlings from reaching sunlight before they exhaust their stored nutrients. Also during sprouting and early growth, the young plants may be buried deeply.

When submerged annual aquatic plants or low-growing plants become covered by sediment before their seeds reach maturity, the chances for successful seed production are minimal. Regrowth during the following season then may depend primarily on seed dispersal from other marsh areas. With the drastically reduced extent of freshwater tidal marsh along the Delaware River, the movement of seeds from marsh to marsh has become less probable than it was prior to urbanization. If significant sedimentation with concurrent burial of existing wetland plants should occur at Fish House Cove, the perennial common reed grass stands probably will be able to extend their percentage occupancy of the marsh by displacing currently prominent annuals such as wildrice. The present diversity and vigor of the Cove's vegetation indicates either lack of appreciable sedimentation to date or effective resistance to its impact.

The impact of two approved projects within 2,500 feet of the Cove potentially could be deleterious. The Hess Corporation plans to place approximately 380,000 cubic yards of dredged river bottom on an adjacent upland site. The Vineland Construction Co. project will deposit over 100,000 cubic yards of demolition debris on the western shore of the Cove. Impacts on the wetlands vegetation are probable but unquantifiable at this time, given the past history of encroachment on the Cove by unconfined fill from the upland.

Leaching of Fill

Fill placed on areas adjacent to Fish House Cove may be leached by groundwater, and the leachate may enter the marsh system. Should the leachate contain any chemical components toxic to marsh organisms, a chronic distress may ensue (Darnell 1976). This condition

could be evidenced by a general lowered vigor and productivity of local aquatic plants and animals.

The probability that hazardous substances will leach from adjacent fill into any remaining marsh, or into the Delaware River directly, will vary with the nature of the fill material. Uncontaminated soil material or crushed stone would have the least potential as a source of hazardous leachate.

A sanitary landfill (that is, a dump for miscellaneous wastes at which soil cover is spread at relatively frequent intervals) would have substantial hazardous leachate potential. Because of the small risk of detection and great economic incentive for dumping toxic chemical residues and other known hazardous substances illegally in sanitary landfills in the Delaware Valley (Nordland and Friedman 1979), the use of adjacent lands for sanitary landfills almost certainly would insure that hazardous substances reach the estuarine ecosystem at Fish House Cove, even if they are not accepted "legally" or "officially" by the landfill operator. At the time of the 5 September 1979 collection of water samples at Fish House Cove for this report, an active, apparently unauthorized dump was observed to occupy at least 2 acres adjacent to the Petty Island Backchannel just north of 29th Street in Camden. At least three pickup trucks offloaded at the dump while WAPORA personnel were launching and removing their boat and during the interval between the two tidal-stage samplings. Miscellaneous rubbish appeared to have been deposited here for many years.

Salinity Changes

The current (1979) vegetation of Fish House Cove is a freshwater tidal marsh. The species composition of the marsh is subject to change, if the salinity of the Cove water changes.

The Delaware River, like other major estuaries, has a current of relatively dense, saline water at depth that flows upriver toward the Philadelphia-Camden region even though the prevailing surface flow is downriver toward Delaware Bay and the Atlantic Ocean. The vertical, horizontal, and longitudinal movements of the salt wedge in the Delaware River are affected by the interaction of many physical forces including tidal action, volume of freshwater flow, channel morphology, and atmospheric pressure gradients. Locally, the distribution of salt and fresh waters can be affected by the mixing action of ship and small boat propellers. Industrial discharges of wastewater used for cooling or other purposes also can affect salinity in their mixing zones.

The salt wedge of the Delaware River channel extends upstream from Fish House Cove during summer periods of low freshwater flow. No measurements of salinity in Fish House Cove over an annual or longer-term cycle are available. It is evident from the vegetation, however, that saline water was not common at the Cove during the 1970's.

The salinity of the waters in the Cove could increase as a result of one or more of the following activities:

- Channel dredging that increases hydraulic efficiency in the Delaware River
- Increased tanker or other ship traffic in the Cove itself
- Industrial discharges at the Cove
- Diversions of freshwater from the upper Delaware River with consumptive use or interbasin transfer to the Schuylkill River or other streams
- Drought that reduces freshwater inflow.

It is impossible to predict precisely what effects the increase in salinity would have on the vegetation of the Cove, because the species present have varying physiological tolerances for exposure to brackish or saline water. No detailed examination of the literature on marsh plant physiology could be conducted within the constraints of this report. It is reasonable to expect that the submerged aquatics would be most susceptible to an increased salinity regime, particularly if the change in salinity were accompanied by an increase in turbidity and sedimentation. Wildrice also would be expected to experience an adverse impact, with a consequent decrease in the present high value of the marsh to waterfowl and other wildlife. Common reed grass could expand its distribution, with a decline in the present high species diversity.

Hydrocarbon or Petrochemical Spillage

Detailed information and data concerning each wetland plant species and its threshold level or toxic level for each type of crude and/or refined petrochemical were not compiled because of the limited scope of this report. From the limited literature review, however, it can be stated with certainty that the presence of crude oil, petroleum products, or petrochemicals in a freshwater marsh system will be deleterious in a proportional relationship to the quantity of that material present. The degree of damage will be determined largely by the time of year, the times during the tidal cycle when the chemicals or oil are present, the type of chemicals present and their acute toxicity, the persistence of the chemicals, the relative buoyancy of the chemicals, and the degree to which the chemicals become incorporated into the bottom substrate. No beneficial impacts would be anticipated. At present, no obvious adverse effect on the Cove's vegetation is noticeable. The observed ambient oil and grease concentrations in the water were less than 2 mg/l.

Generally, annual marsh plants will be affected by catastrophic spills in larger numbers and to a greater degree than perennial marsh plants (Burk 1976). Species including arrowheads and sensitive fern may exhibit rapid die-off and recovery after a spill. Bur marigold, blue flag, and smartweeds, however, may become extinct in the marsh. Sensitive fern, pickerelweed, and wildrice reasonably could be expected to become reduced drastically in numbers after a spill. Effects upon the submerged aquatics

and smaller emergent species would depend upon the timing of the spill in relation to the tides.

Any spill that would result in the deposition of petrochemicals on the substrate of the marsh at low tide could have prolonged effects of a drastic nature. As with any reaction by natural systems after damage by pollution, the most tolerant, weedy species will be the first species to reinvade an area after other species are killed. In the case of Fish House Cove this would more than likely mean a replacement of wildrice and the other high-value marsh plants by common reed or by other marsh plants with relatively low value to wildlife.

CRITICAL AREAS

The entire vegetated and unvegetated wetland area at Fish House Cove should be considered a critical area for several reasons. The freshwater riverine tidal marsh vegetation type has become scarce in the Delaware Valley region due to large-scale dredge spoil deposition and the establishment of landfills on tidal marshes, particularly during the past 25 years. Fish House Cove is the largest and possibly the most diverse remaining tract of freshwater riverine tidal marsh in surrounding Camden, Gloucester, Burlington, and Bucks Counties. (More extensive, but much disturbed, freshwater wetlands occur at the Tinicum National Environmental Center west of the International Airport in Philadelphia and Delaware Counties, Pennsylvania [JMA 1978a].) From a biological standpoint, the floristic diversity of the Fish House Cove marsh signals high intrinsic and extrinsic value, both as current habitat for wildlife and as an example of species and of vegetation types that were historically common in marshes that bordered the Delaware River in this region.

MITIGATION

If the wetlands of Fish House Cove are to be protected, the adjacent lands above tidal influence also must be protected to provide a buffer and to mitigate against the potential negative effects of siltation from adjacent development; noise and disturbance from construction and operation, and especially from vehicles; illegal refuse and toxic waste dumping; and other urban industrial insults to the environment that may degrade the quality of the existing marsh system. It is unlikely that encroachments into the wetlands at the Cove will be allowed, given current State and Federal policies regarding wetland and floodplain preservation, if those policies are conscientiously enforced.

If the marsh is preserved at Fish House Cove, the question of reestablishing a marsh elsewhere as mitigation for filling will not arise. The reestablishment of freshwater tidal marshes is not well understood technically (McCormick and Somes 1979), and the diverse species composition of the existing marsh cannot be replicated elsewhere except through extraordinary effort.

II. WILDLIFE

This section of the report documents the wildlife resources of Fish House Cove, describes the significance of the area for wildlife, describes the probable effects of energy-related activities on wildlife, and suggests measures to mitigate any potential adverse impacts from surrounding activities on wildlife at Fish House Cove.

CONTEMPORARY WILDLIFE RESOURCES

The preponderance of available wildlife data concern birds. General data also exist concerning amphibians, reptiles, fish, and mammals.

Birds

Kenneth Tischner, a local naturalist, has made extensive observations of the birds at Fish House Cove. Tischner conducted daily observations of birds at Fish House Cove from 16 June 1972 to 15 June 1973 and made periodic observations before and after his year-long study (personal communication and unpublished data). In addition to these observations, Camden County Environmental Agency staff have made periodic observations of birds at the Cove from 1976 to 1979. During the period 1972 through 1979, 229 species of birds were observed at the Cove (Table 4). Table 4 also includes an indication of abundance by season for each species. The numbers represent the highest concentration recorded in one day during the appropriate season. For example, no more than one common loon was observed at the Cove at any time during spring, summer, and autumn, whereas the maximum number of red-necked grebes observed at the Cove in one day during autumn was eight.

Fish House Cove has historically been known as an important area for birds. Quantitative study of waterfowl at the Cove was underway as early as 1918, when Julian Potter made 48 trips to the Cove to census waterfowl populations (Coman 1944). During 1943 and 1944 Coman (1944) censused waterfowl populations along the Delaware River, including Fish House Cove. Coman found Fish House Cove to be one of ten major points of concentration of waterfowl along the New Jersey side of the River from Pennsauken to Salem. Manners (1946) observed and recorded shorebird populations along the River in the vicinity of Philadelphia. Fish House Cove was identified as one of nine major areas frequented by shorebirds in this area. Jack McCormick & Associates, Inc. (1974) noted that Fish House Cove had been identified as specially significant habitat for wildlife in a comprehensive resource inventory of Camden County.

Amphibians, Reptiles, and Fish

The open water, marsh, and upland edge habitats at Fish House Cove are likely to support species of amphibians and reptiles common to these habitats elsewhere in western Camden County. Field studies may reveal other species of herpetofauna in the environs of the Cove (Table 5). Fish collected from the Delaware in the vicinity of the Cove are listed in Table 6.

Table 4. Bird species known to occur at Fish House Cove, Camden County, New Jersey (Tischner and Camden County Environmental Agency, unpublished data). Abundance determined by highest number observed in one day during appropriate season (x indicates species present but not counted).

SPECIES	ABUNDANCE BY SEASON			
	Spring Mar.-May	Summer (June-Aug.)	Autumn (Sept.-Nov.)	Winter (Dec.-Feb.)
Common loon	1	1	1	
Red-throated loon		1	1	
Red-necked grebe			8	1
Horned grebe	6		15	2
Pied-billed grebe	2			
Double crested cormorant	41	7	5	
Great blue heron	2	5	4	1
Green heron	2	3	3	
Cattle egret			x	
Great egret		5	4	1
Snowy egret	2	4	1	
Louisiana heron		2	1	
Black-crowned night heron	1	2	x	
Least bittern		1		
American bittern				1
Whistling swan				24
Canada goose	61	18	148	32
Brant			4	1
Snow goose			1	4
Mallard	45	114	155	134
Black duck	26	77	48	44
Gadwall	3		7	2
Pintail	50	1	541	400
Green-winged teal	2		15	2
Blue-winged teal	7	8	20	
American wigeon	4		17	53
Northern shoveler	4		1	
Wood duck	7	5	6	
Redhead	5		28	28
Ring-necked duck	20		7	32

Table 4. Bird species known to occur at Fish House Cove (continued).

SPECIES	ABUNDANCE BY SEASON			
	Spring Mar.-May	Summer (June-Aug.)	Autumn (Sept.-Nov.)	Winter (Dec.-Feb.)
Canvasback	550		97	810
Greater scaup	145		20	200
Lesser scaup	700	5	210	750
Common goldeneye	12		6	25
Bufflehead	12		53	13
Oldsquaw			12	5
Harlequin duck			1	
White-winged scoter			3	1
Common scoter	2		5	
Ruddy duck	4,000	13	7,107	6,025
Hooded merganser	2		1	
Common merganser	4		2	5
Red-breasted merganser	8	8	11	10
Turkey vulture		1	2	
Sharp-shinned hawk			1	
Red-tailed hawk				4
Red-shouldered hawk				1
Broad-winged hawk	1		x	
Marsh hawk				1
Osprey	x		1	
Merlin	1			
American kestrel	1	2	2	4
Bobwhite	1	x		1
Ring-necked pheasant	1		x	4
King rail		1		
Virginia rail			1	
Common gallinule		2		
American coot	1	x	10	
Semipalmated plover		25		
Killdeer	x	x	x	6
Black-bellied plover		1		
American woodcock	5	x		9
Common snipe	5			1
Whimbrel	2			
Upland sandpiper	x			

Table 4. Bird species known to occur at Fish House Cove (continued).

SPECIES	ABUNDANCE BY SEASON			
	Spring Mar.-May	Summer (June-Aug.)	Autumn (Sept.-Nov.)	Winter (Dec.-Feb.)
Spotted sandpiper	6	4	x	
Solitary sandpiper	x	1		
Willet	x			
Greater yellowlegs	32	43	x	
Lesser yellowlegs	2	15	x	
Pectoral sandpiper			12	
White-rumped sandpiper		25		
Least sandpiper		1,000		
Dunlin		3		
Short-billed dowitcher		2		
Stilt sandpiper			5	
Semipalmated sandpiper	x	2,000	8	
Western sandpiper		18		
Sanderling		25		
Great black-backed gull	1	10	x	10
Herring gull	21	40	x	184
Ring-billed gull	x	7	42	50
Laughing gull	x	4	x	
Bonaparte's gull	8		55	1
Forster's tern			8	
Common tern	x	1	4	
Least tern		1	11	
Royal tern	x		11	
Caspian tern		1		
Black tern		x		
Black skimmer		1		
Rock dove	8	x	x	8
Mourning dove	24	x	x	8
Yellow-billed cuckoo	x	x	3	
Black-billed cuckoo	1	x		
Screech owl				2
Chimney swift	x	x	1	
Ruby-throated hummingbird	1			
Belted kingfisher	x	x	x	
Common flicker	2	4	1	1

Table 4. Bird species known to occur at Fish House Cove (continued).

SPECIES	ABUNDANCE BY SEASON			
	Spring Mar.-May	Summer (June-Aug.)	Autumn (Sept.-Nov.)	Winter (Dec.-Feb.)
Red-bellied sapsucker	2		2	
Hairy woodpecker	x	x	x	7
Downy woodpecker	x	x	x	10
Eastern kingbird	1	18	x	
Great crested flycatcher	1		x	
Eastern phoebe	2	x	2	
Yellow-bellied flycatcher	1		x	
Acadian flycatcher	x	1		
Traill's flycatcher	x	x		
Least flycatcher			x	
Eastern wood pewee	1	x	x	
Horned lark	x			
Tree swallow	x	x	x	
Bank swallow	x	x		
Rough-winged swallow	1	x		
Barn swallow	1	x	x	
Cliff swallow	2			
Purple martin	x	x		
Blue jay	3	x	400	46
Common crow	4	x	x	102
Fish crow	x	6		
Black-capped chickadee		x	1	x
Tufted titmouse	x	x	1	x
White-breasted nuthatch	1		2	1
Brown creeper	1	x	2	1
House wren	1	x	x	
Winter wren				1
Carolina wren	x	x	6	5
Long-billed marsh wren	x	2	x	
Short-billed marsh wren	1			
Mockingbird	x	x	x	2
Catbird	1	x	x	
Brown thrasher	1	x	x	
American robin	4	x	2	2
Wood thrush	1	x	x	

Table 4. Bird species known to occur at Fish House Cove (continued).

SPECIES	ABUNDANCE BY SEASON			
	Spring Mar.-May	Summer (June-Aug.)	Autumn (Sept.-Nov.)	Winter (Dec.-Feb.)
Hermit thrush	4			
Swainson's thrush	1			
Gray-cheeked thrush	4		1	
Veery	4		1	
Eastern bluebird		1		
Blue-gray gnatcatcher	1			
Golden-crowned kinglet	3		x	3
Ruby-crowned kinglet	1		2	1
Cedar waxwing	x		50	1
Starling	95	x	x	72
White-eyed vireo	x	1		
Yellow-throated vireo	2	2		
Solitary vireo	6		x	
Red-eyed vireo	1	x	6	
Philadelphia vireo	1		x	
Warbling vireo	2		x	
Black and white warbler	20	4	19	
Prothonotary warbler	1	1		
Worm-eating warbler	2	1	2	
Golden-winged warbler	3			
Blue-winged warbler	3	1		
Brewster's warbler			1	
Tennessee warbler	8	1	2	
Nashville warbler	1	3	1	
Parula warbler	20	1	6	
Yellow warbler	23	2	6	
Magnolia warbler	10		1	
Cape May warbler	6	10	12	
Black-throated blue warbler	9		3	
Cerulean warbler	1			
Yellow-rumped warbler	70		25	1
Black-throated green warbler	25		4	
Blackburnian warbler	4		3	
Yellow-throated warbler	1			
Chestnut-sided warbler	8		2	

Table 4. Bird species known to occur at Fish House Cove (continued).

SPECIES	ABUNDANCE BY SEASON			
	Spring Mar.-May	Summer (June-Aug.)	Autumn (Sept.-Nov.)	Winter (Dec.-Feb.)
Baybreasted warbler	6		2	
Blackpoll warbler	31	2	3	
Pine warbler	4	7	12	
Prairie warbler	3		4	
Palm warbler	3	1	6	
Ovenbird	14	1	3	
Northern waterthrush	4		2	
Louisiana waterthrush	1			
Kentucky warbler	1			
Connecticut warbler			1	
Morning warbler	1	1	2	
Common yellowthroat	18	2	5	
Yellow-breasted chat	2			
Hooded warbler	1			
Wilson's warbler	6	1	2	
Canada warbler	6	1	2	
American redstart	42	2	12	
House sparrow	14	x	x	65
Bobolink		1	2	
Eastern meadowlark	1	x		
Red-winged blackbird	120	x	x	18
Orchard oriole	1	1		
Northern oriole	1	14	x	
Rusty blackbird	x		1	x
Common grackle	15	x	x	3
Boat-tailed grackle		x		
Brown-headed cowbird	2	x	x	46
Scarlet tanager	12		x	
Summer tanager	1			
Cardinal	x	x	x	1
Rose-breasted grosbeak	8		3	
Indigo bunting	x			
Dickcissel	x			
Evening grosbeak	3		1	2
Purple finch	x		9	71

Table 4. Bird species known to occur at Fish House Cove (concluded).

SPECIES	ABUNDANCE BY SEASON			
	Spring Mar.-May	Summer (June-Aug.)	Autumn (Sept.-Nov.)	Winter (Dec.-Feb.)
House finch			4	7
Common redpoll	2			
Pine siskin	40			
American goldfinch	x	20	21	14
White-winged crossbill	2			
Rufous-sided towhee	17	x	x	1
Savannah sparrow	1	x	x	1
Grasshopper sparrow	1	x	x	
Vesper sparrow		1		
Lark sparrow		1		
Dark-eyed junco	1		28	x
Tree sparrow	12		15	2
Chipping sparrow	x	2	3	
Field sparrow	x	x	x	6
White-crowned sparrow	1		2	
White-throated sparrow	20		x	10
Fox sparrow	4		8	1
Lincoln's sparrow	1		1	
Swamp sparrow	2	x	22	4
Song sparrow	42	x	50	45
Snow bunting			4	

Table 5. Amphibians and reptiles known (*) or likely to occur at Fish House Cove, Camden County, New Jersey (Grant 1966, Jack McCormick & Associates, Inc. 1974, Conant 1975).

<u>Common Name</u>	<u>Scientific Name</u>
Fowlers toad	Bufo woodhousei fowleri
Northern cricket frog	Acris crepitans
Spring peeper	Hyla crucifer
Bullfrog	Rana catesbeiana
Green frog	Rana clamitans melanota
Southern leopard frog	Rana utricularia
Snapping turtle*	Chelydra serpentina
Stinkpot	Sternotherus odoratus
Eastern mud turtle	Kinosternon subrubrum
Painted turtle	Chrysemys picta
Red-bellied turtle	Chrysemys rubriventris
Northern water snake	Natrix sipedon
Eastern garter snake	Thamnophis sirtalis
Eastern ribbon snake	Thamnophis sauritus
Northern black racer	Coluber constrictor

Table 6. List of fishes collected from the Delaware River on industrial screens (River Miles 81.2, 97.5, 101.2, 104.3) in 1976 (Tyrawski 1979:491).

Bowfin	Banded killifish
American eel	Mummichog
Herring	Tidewater silverside
Blueback herring	White perch
Alewife	Striped bass
American shad	Sunfish
Atlantic menhaden	Green sunfish
Bay anchovy	Bluegill
Chain pickerel	Sunfish hybrid
Goldfish	Largemouth bass
Carp	White crappie
Silvery minnow	Black crappie
Golden shiner	Yellow perch
Spottail shiner	Bluefish
Minnow hybrid	Spot
White sucker	Atlantic croaker
White catfish	Naked goby
Brown bullhead	Hogchoker
Channel catfish	

Fish House Cove potentially is a productive area for aquatic organisms. Such tidal areas of mudflats and emergent vegetation historically provided excellent habitat for fish and aquatic insects. Hydrocarbons in the sediments may or may not reduce the habitat value of the Cove at present.

Mammals

Habitat conditions at Fish House Cove are likely to support ten species of terrestrial mammals commonly associated with marsh habitats and upland edge situations. Four additional species may also occur on the site and are known to occur elsewhere in Camden County (Table 7). Suitable roosting habitat for bats is limited or nonexistent in the Cove area. Eight species which range over much of the region are likely to occur over or near the site during foraging flights for insects from adjacent areas where suitable roosting habitats exist (Table 8).

SIGNIFICANCE OF FISH HOUSE COVE FOR BIRDS

Because it is one of the few stopovers along the Atlantic flyway in this developed area, Fish House Cove can be regarded as an international resource. The 229 species of birds observed at the Cove represent 88% of the total number of species estimated for Camden County by Jack McCormick & Associates, Inc. (1974). Also, the total numbers of birds that occur at the Cove are significant. Large numbers of migrating waterfowl, especially ruddy ducks (over 7,000 individuals at one time), pintail, scaup, and canvasback, are found seasonally in and near the Cove.

Fish House Cove also provides suitable habitat for significant numbers of grebes, herons, shorebirds, warblers, finches, and sparrows during breeding, migrating, and wintering seasons. Waterfowl inhabit the Cove area virtually year-round.

The historical observations of waterfowl by Potter and Coman (Coman 1944) and the recent observations of waterfowl by Tischner (unpublished data) provide data for comparing trends in use of the Cove area by waterfowl (Table 9). Of particular interest is the increase in species and numbers of waterfowl observed at the site from 1918 to 1973. In 1918, five species and a total of 1,056 ducks were recorded; in 1943-1944, 12 species and a total of 16,294 ducks were recorded; in 1972-1973, 20 species of waterfowl (2 species of geese, 16 species of ducks, and 2 species of mergansers) were recorded. The increase in species and numbers populations indicate the increased significance of the Cove to waterfowl.

The most abundant duck at Fish House Cove is the ruddy duck. The Cove provides important wintering habitat for this species. In winter, ruddy ducks are found in New Jersey primarily along the Delaware River (Fred Ferrigno, NJDEP, unpublished data). Mid-winter inventories of waterfowl in New Jersey recorded between 3,000 and 8,500 ruddy ducks from 1972 to 1977. Of the total 8,500 ruddy ducks observed during January 1977 in New Jersey, 7,200 were located along the Delaware River between Paulsboro and Delanco.

Table 7. Mammal species known (*) or likely to occur on or near Fish House Cove, Camden County, New Jersey (Burt and Grossenheider 1976 and Jack McCormick & Associates, Inc. 1974).

Masked shrew (*Sorex cinereus*)
 Shorttail shrew (*Blarina brevicauda*)
 Eastern mole (*Scalopus aquaticus*)
 Raccoon* (*Procyon lotor*)
 White-footed mouse (*Peromyscus leucopus*)

 Meadow vole (*Microtus pennsylvanicus*)
 Muskrat* (*Ondatra zibethica*)
 Norway rat (*Rattus norvegicus*)
 House mouse (*Mus musculus*)
 Eastern cottontail* (*Sylvilagus floridanus*)

Other small mammals which also may occur on the Fish House Cove project site:

Opossum (*Didelphis marsupialis*)
 Least shrew (*Cryptotis parva*)
 Starnose mole (*Condylura cristata*)
 Striped skunk (*Mephitis mephitis*)

Table 8. Species of bats which probably occur over or near Fish Hose Cove, Camden County, New Jersey (Burt and Grossenehider 1976, Jack McCormick & Associates, Inc. 1974).

Little brown myotis (*Myotis lucifugus*)
 Keen's myotis (*Myotis keeni*)
 Small-footed myotis (*Myotis subulatus*)
 Silver-haired bat (*Lasionycteris noctivagans*)
 Eastern pipistrelle (*Pipistrellus subflavus*)

 Big brown bat (*Eptesicus fuscus*)
 Red bat (*Lasiurus borealis*)
 Hoary bat (*Lasiurus cinereus*)

Table 9. Comparison of waterfowl counts at Fish House Cove, Camden County, New Jersey in 1918, 1943-1944 (Coman 1944) and 1972-1973 (Tischner, unpublished data). Numbers represent total number of individuals observed in all trips. The dates of the 22 trips in 1943-1944 were used to select representative data from 1972-1973. ("x" indicates species present but not counted). The Coman data are generalized and do not record abundance by season. This table is useful as an indicator of gross abundance of waterfowl at various times during this century.

SPECIES	1918 (48 trips)	1943-1944 (22 trips)	1972-1973 (22 trips)
Canada goose			34
Brant			2
Mallard		x	229
Black duck	72	4,444	87
Gadwall			9
Pintail	17	9,766	368
Green-winged teal			1
Blue-winged teal		x	9
American wigeon		x	20
Northern shoveler		x	
Wood duck			11
Redhead	6	4	5
Ring-necked duck			8
Canvasback	x	1,653	
Scaup	452	698	1,754
Common goldeneye		x	5
Bufflehead		x	26
White-winged scoter			3
Ruddy duck			17,258
Red-breasted merganser			4
Common merganser	437	59	1

Fish House Cove is one of the major areas for waterfowl within this section of the river.

The data collected by Manners (1946) and Tischner (unpublished) provide a means to compare shorebird populations at Fish House Cove between the 1936-1945 and 1972-1973 periods (Table 10). Although the numbers of species and of individuals were larger in 1936-1945, these numbers represent shorebird populations in the entire Philadelphia region during a ten-year period. Shorebirds observed at Fish House Cove in 1972-1973 indicate that the Cove provides suitable habitat for most of the shorebirds found along the Delaware River.

Thirty-four endangered, threatened, undetermined, or declining species of wildlife in New Jersey have been observed at Fish House Cove (Table 11). Although many of these species have been recorded only occasionally at the Cove, several species (great blue heron, black duck, and ruddy duck) are regularly found at the Cove. The occurrence of these endangered, threatened, undetermined, and declining species at Fish House Cove again demonstrates the significance of the Cove to wildlife populations.

EFFECTS OF ONGOING AND PROPOSED HUMAN ACTIVITIES ON WILDLIFE IN THE VICINITY OF FISH HOUSE COVE

At the present time the single most detrimental impact on the Cove's wildlife is caused by the effluent discharged by the Philadelphia Northeast Water Pollution Control Project located directly across the river from the Cove and from the Pennsauken and Camden Sewage Treatment Plants located immediately upstream and downstream from the Cove on the New Jersey shore. The oxygen demand generated by this effluent probably results in stress conditions for the resident aquatic biota and contributes significantly to the degraded water quality as evidenced by several sampling programs undertaken historically in this area of the Delaware River.

In a sampling program conducted between August 1976 and March 1977 between Marcus Hook and Trenton, nearly 100 chemical compounds including numerous industrial contaminants were found in the water (Sheldon and Hites 1978). No direct impact on the Cove's wildlife caused by these substances can be demonstrated, on the basis of current information, but their effects also cannot be discounted entirely without further study.

Ongoing energy-related activities at the three nearby oil storage facilities may be expected to contribute generally to increased water turbidity, accelerated sedimentation, changes in pH values, increased chemical oxygen demand, increased biological oxygen demand, and temperature (Darnell 1976). NPDES permit records show discharges of oil and grease as well. The limited sampling for this study could establish neither a short or long term detrimental impact on local wildlife caused by these oil-related facilities.

Table 10. Comparison of shorebird counts along Delaware River in the entire Philadelphia area during 1936-1945 (Manners 1946) and at Fish House Cove during 1972-1973 (Tischner unpublished). Numbers represent highest number observed at one time during study period ("x" indicates species present but not counted). Manner's data are presented as recorded. Abundance by season is not available.

SPECIES	1936-1945	1972-1973
Semipalmated plover	50	25
Killdeer	100	6
Golden plover	5	-
Black-bellied plover	8	1
Ruddy turnstone	2	-
American woodcock	7	9
Common snipe	20	5
Hudsonian curlew (Whimbrel)	3	2
Upland sandpiper	25	x
Spotted sandpiper	20	6
Solitary sandpiper	10	1
Willet	1	x
Greater yellowlegs	73	43
Lesser yellowlegs	250	15
Pectoral sandpiper	100	12
White-rumped sandpiper	25	25
Baird's sandpiper	3	-
Least sandpiper	300	1,000
Dunlin	30	3
Dowitcher	20	2
Stilt sandpiper	15	5
Semipalmated sandpiper	25,000	2,000
Western sandpiper	60	18
Hudsonian godwit	3	-
Sanderling	3	25
Avocet	7	-
Wilson's phalarope	9	-

Table 11. New Jersey endangered, threatened, peripheral, status undetermined, and declining species (Cookingham 1979) recorded from Fish House Cove during 1972-1975 (Tischner unpublished).

Endangered Bird Species

Osprey
Least tern
Black skimmer

Threatened Bird Species

Pied-billed grebe
Great blue heron
Red-shouldered hawk
Marsh hawk
Merlin
Upland sandpiper (plover)
Cliff swallow
Short-billed marsh wren
Bobolink
Savannah sparrow
Grasshopper sparrow
Vesper sparrow

Undetermined Bird Species

Black duck
Ruddy duck
Sharp-shinned hawk
King rail
American coot
Common snipe
Eastern bluebird

Undetermined Amphibian

Northern cricket frog

Undetermined Reptiles

Red-bellied turtle
Northern black racer

Undetermined Mammals

Hoary bat
Least shrew
Starnose mole
Keen's myotis
Silver-haired bat
Eastern pipistrelle

Declining Bird Species

Red-necked grebe
American bittern
Least bittern
Common tern
Least flycatcher
Horned lark
Purple martin
White-eyed vireo
Warbling vireo
Yellow-breasted chat
Hooded warbler
Eastern meadowlark

Peripheral Fish

Atlantic croaker

Table 12. Oil-sensitive ornithological populations of New Jersey, (Clean Atlantic Associates 1978) which occur at Fish House Cove (Tischner unpublished).

Swimming, Wading, and Diving Birds

Common loon	Greater scaup
Red-throated loon	Lesser scaup
Red-necked grebe	Common goldeneye
Horned grebe	Bufflehead
Pied-billed grebe	Oldsquaw
Double-crested cormorant	Harlequin duck
Great blue heron	White-winged scoter
Great egret	Common scoter
Snowy egret	Ruddy duck
Louisiana heron	Hooded merganser
Green heron	Common merganser
Black-crowned night heron	Red-breasted merganser
American bittern	King rail
Least bittern	Virginia rail
Whistling swan	Common gallinule
Canada goose	American coot
Brant	Belted kingfisher
Snow goose	Great black-backed gull
Mallard	Herring gull
Black duck	Ring-billed gull
Gadwall	Laughing gull
Pintail	Bonaparte's gull
Green-winged teal	Forster's tern
Blue-winged teal	Common tern
American widgeon	Least tern
Northern shoveller	Royal tern
Redhead	Caspian tern
Ring-necked duck	Black tern
Canvasback	Black skimmer

Shorebirds

Killdeer	White-rumped sandpiper
Black-bellied plover	Least sandpiper
Upland sandpiper (plover)	Dunlin
Semipalmated plover	Short-billed dowitcher
Spotted sandpiper	Stilt sandpiper
Solitary sandpiper	Semipalmated sandpiper
Willet	Western sandpiper
Greater yellowlegs	Sanderling
Lesser yellowlegs	
Pectoral sandpiper	

Endangered Bird

Osprey

Future energy-related impacts potentially include increased sedimentation and turbidity from the proposed construction of a marine terminal by the Hess Company to accommodate tankers, the largest tankers to penetrate this far upstream. The operations at this terminal are expected to affect the Cove negatively. Additionally, the proposed 35-acre landfill project on the western shore of the Cove is expected to increase sedimentation and turbidity in and around the Cove.

Serious adverse effects on wildlife related to energy facilities could result from an oil spill into the Delaware River near Fish House Cove. At least 97 bird species that have been observed at Fish House Cove could be seriously affected by an oil spill in three groups - 78 swimming, wading, and diving birds; 18 shorebirds; and 1 endangered bird (Table 12). These species include those birds most dependent on the open water and marsh in the Cove.

Areas such as Fish House Cove are particularly susceptible to damage from oil spills. Oil spilled in adjacent areas of the Delaware River would enter Fish House Cove and probably tend to accumulate. The limited flushing and physical obstruction provided by emergent vegetation could induce oil retention. Such an occurrence could lead to the loss of aquatic biota and other wildlife through toxic effects and physical damage.

Avoidance and Mitigation of Adverse Impacts

Continued wildlife utilization of Fish House Cove will be a function of the quality and quantity of habitat available. Freshwater marsh, mudflats, and shallow, open water are the major wildlife habitats at the Cove. Promulgation of the wetland maps of Fish House Cove by the State of New Jersey could provide increased State control of the potential users of the site through the existing regulatory framework of the New Jersey Department of Environmental Protection, which currently is based only on the waterfront development permit and water pollution control law. The Philadelphia District, Army Corps of Engineers, recently has intensified its surveillance and enforcement efforts under Section 404 of the Clean Water Act. Full enforcement of the Wetlands Act and Section 404 will minimize the loss of fish and other wildlife habitat.

Discharges to the Delaware River from existing and future facilities both upstream and downstream from the Cove can be controlled by both the US Environmental Protection Agency and the New Jersey Department of Environmental Protection. Controls on the pollutants which may enter the Delaware River must be enforced by these agencies and by the Delaware River Basin Commission to protect the Cove habitat from degradation.

Specific mitigative measures cannot be designed without prior knowledge of the nature, location, size, configuration, or operating procedure associated with any proposed energy-related facilities. In general, the existing oil-related facilities could be encouraged to develop joint spill control operations to prevent damage to wildlife. They could also be urged to join the Delaware River Cooperative formed by 13 industries to minimize any damage that could result from oil spills on the River between Philadelphia and the Delaware Memorial Bridge. The Cooperative also provides for oiled bird rehabilitation.

III. WATER QUALITY

This chapter first presents generally the findings of previous investigations of Delaware River water quality and then reports on established surface water uses and standards. The results of grab samples from three stations analyzed for this report are detailed and discussed, and point sources of pollutants are identified. Then the water quality at the Cove is discussed in the context of energy-related facilities, and potential future mitigation measures are noted.

PREVIOUS INVESTIGATIONS

Four documents were supplied by the Camden County Environmental Agency to the consultant on 25 September 1979. These secondary sources consisted of water quality data extracted from published documents (JGRA 1976, DRBC 1976, and USGS 1978) together with tidal information (USGS 1979). These sources provide historical water quality data for several water quality monitoring stations in the general vicinity of Fish House Cove for the summer of 1970, for the calendar year 1974, and for the water year 1977 (October 1976 through September 1977). These sources, along with other available studies (DVRPC 1978, Tyrawski 1979, and WAPORA 1979a) collectively describe the historical water quality as summarized in the following paragraphs.

The Delaware River between Philadelphia, Pennsylvania, and Wilmington, Delaware, currently is described as a highly polluted environment virtually devoid of healthy aquatic communities and safe human contact recreation resources (DVRPC 1978). Low concentrations of dissolved oxygen occur frequently throughout the summer and early autumn; concentrations of fecal coliform bacteria are high year-round. Philadelphia sewage treatment plants contribute more than two thirds of the total oxygen-demanding pollutant load in the immediate vicinity of the plant discharges. Similarly, during dry weather periods, these facilities contribute nearly 90% of the fecal coliform bacteria between Trenton, New Jersey, and Lisbon Point, Delaware (DVRPC 1978). There are several sewage treatment plants in the near vicinity of Fish House Cove.

The quality of the water in the Delaware River adjacent to Fish House Cove generally is better than that farther downstream in Zone 3. Data on water quality collected from the River in the vicinity of Fish House Cove by the Philadelphia Water Department (1976 through June 1978) and by Battelle Laboratories (May-June 1978) indicate the existence of continuing pollution. The applicable water quality criteria for both minimum daily and seasonal average concentrations of dissolved oxygen occasionally are violated in this section of the Delaware River.

The concentrations of fecal coliform bacteria frequently and grossly exceed values recommended by the State, often by more than one order of magnitude (Philadelphia Water Department 1978). Also, concentrations of residual chlorine and cyanides measured by Battelle Laboratories (1978)

exceed those concentrations considered safe for aquatic organisms (2.0 and 5.0 ug/l, respectively; USEPA 1976). With the exception of occasional single analyses, the concentrations of metals measured in the waters of the Delaware River were within the guidelines recommended for the protection of aquatic life by USEPA (1976). Thus, the Delaware River in the vicinity of Fish House Cove appears to be moderately polluted by oxygen-demanding substances and toxic materials and highly contaminated by fecal coliform bacteria.

Numerous industrial organic chemicals also are present in this reach of the Delaware River. Isoprenoids, steroids, fatty acids and esters, aromatic hydrocarbons, phenols, chlorinated compounds, ethylene glycol derivatives, and plasticizers have been detected, with generally higher concentrations present during winter months than during summer (Sheldon and Hites 1978). Some of the organics are affected by secondary treatment at the Philadelphia Northeast Sewage Treatment Plant; others are merely reduced in concentration by dilution. Some that pass through the Wastewater Plant are returned to Philadelphia drinking water at the Torresdale drinking water facility (Sheldon and Hites 1979). During 1979 the Camden County Department of Health announced that all streams in the County between the New Jersey Turnpike and the Delaware River contained sufficient chlordane that fish from the streams were not recommended for human consumption. The Health Department study did not comprehend Fish House Cove or the Delaware River.

WATER QUALITY STANDARDS AND USES

The Delaware River Basin Commission has issued water quality standards for the Delaware River. Effluent discharges into the Delaware River must comply with these standards, and essentially the same standards have been adopted by the New Jersey Department of Environmental Protection.

Fish House Cove is located approximately 103.5 River Miles from the mouth of the Delaware Estuary (Figure 18). The Cove is near the center of Water Quality Zone 3 as designated by the Delaware River Basin Commission. Zone 3 extends from River Mile 95.0 to River Mile 108.4. The Zone 3 stream water quality standards were developed to protect designated uses (Table 13).

WATER QUALITY ANALYSES DURING 1979

Experienced personnel of the Jack McCormick and Associates Division of WAPORA collected and analyzed three surface water quality samples from Fish House Cove at both low tide and high tide conditions on 5 September 1979. The tidal range was exceptionally wide on 5 September, a period of spring tides. Parameters reported are those mandated by the Camden County Environmental Agency. Station locations are indicated in Figure 1. All samples were obtained from a boat at points 1 foot below the water surface in order to maximize the probability of recovering hydrocarbons. Analyses were by Standard Methods (APHA 1975).

Table 13. Established water uses and stream water quality standards for Zone 3 of the Delaware River (DRBC Resolutions 67-7 and 74-1; NJAC 7: 9-4 et seq.). Standards cited here are the most stringent applicable.

WATER USES TO BE PROTECTED

- Public, industrial, and agricultural water supplies after reasonable treatment
- Maintenance of resident fish and other aquatic biota
- Passage of anadromous fish
- Wildlife
- Secondary contact recreation
- Navigation.

STREAM WATER QUALITY STANDARDS

Dissolved oxygen	>3.5 mg/l, minimum 24-hour average >6.5 mg/l minimum seasonal average, 1 April - 15 June and 16 September - 31 December
Temperature	<5°F (2.8°C) above 1961-1966 average 24-hour gradient, or, <86°F (30.0°C), whichever is less, as measured outside designated heat dissipation areas
pH	>6.5 but <8.5
Phenols	<0.005 mg/l unless exceeded due to natural conditions
Threshold odor number	<24 at 60°C
Synthetic detergents	<1.0 mg/l, 30-day average methylene blue active substances
Radioactivity	<3 pc/l alpha emitters <1,000 pc/l beta emitters
Fecal coliform bacteria	<770 colonies per 100 ml, with samples at such frequency and location as to permit valid interpretation
Total dissolved solids	<133% of background on 1 October 1972, or 500 mg/l, whichever is less

Table 13. Established water uses (concluded).

Turbidity	<u><40</u> JTU 30-day average, and <u><150</u> JTU unless exceeded due to natural conditions
Total alkalinity	>20 and <120 mg/l
Chlorides	<u><200</u> mg/l
Hardness	<u><150</u> mg/l, 30-day average
Floating, suspended, colloidal, & settleable solids; oil, grease; & color	None noticeable in the water or deposited along the shore or on the substrate in quantities detrimental to the natural biota; none that would render the waters unsuitable for the designated uses.
Taste & odor producing substances	None offensive to humans or which would produce offensive tastes and/or odors in water supplies and biota used for human consumption. None which would render the waters unsuitable for the designated uses.
Toxic or deleterious substances	None, either alone or in combination with other substances, in such concentrations as to affect humans or be detrimental to the natural aquatic biota, produce undesirable aquatic biota, or render the waters unsuitable for the designated uses. None which would cause standards for drinking water to be exceeded after appropriate treatment.

The concentration of a toxic substance or combination of
toxic substances in surface waters shall not exceed 5% of
the TL50 value after 96 hours as determined by a Standard
Methods bioassay. In no case shall the following
substances exceed the stated maximum limits:

Arsenic	0.05 mg/l	Lead	0.05 mg/l
Barium	1.0 mg/l	Mercury	0.005 mg/l
Cadmium	0.01 mg/l	Selenium	0.01 mg/l
Chromium VI	0.05 mg/l	Silver	0.05 mg/l

No sediments were collected or analyzed for the present report. WAPORA field personnel noted the apparent high concentrations of oily residues in bottom sediments adjacent to the mainland bank of the Petty Island Back-channel 0.2 mile downriver from Fish House Cove. No observations were made of the sediments in the Cove itself at the times of water sample collection.

The water quality measured at the three locations is relatively similar when compared at the same tidal stages. No systematic differences are apparent between the two tidal stages or among the three sampling locations (Table 14). The data are discussed by parameter in the following paragraphs.

Temperature

Temperatures ranged from 26.0 to 27.5°C. These values are regarded as normal for the Delaware River during early September, and they were within the maximum allowable stream standard (30.0°C).

Salinity and Conductivity

Salinity is a measure of the concentration of dissolved salts in a sample of water. Salinity was calculated from meter measurements of electrical conductivity of the River water. The salinity values at Fish House Cove were very low (on the order of 0.1 ppt) when compared to the typical values for seawater (28-32 ppt). Salinity values consistently were slightly higher at high tide than at low tide at all three stations. The waters at Fish House Cove at the time of observation definitely were fresh. There are no established stream standards for salinity in Zone 3.

pH

The pH values at all locations both at high and low tide were nearly the same. Close to 7.0, they indicate the waters to be neither acidic nor alkaline. The pH standards for Zone 3 waters restrict the acceptable pH range to values between 6.5 and 8.5 standard pH units, and the standards were met in all samples.

Turbidity

The turbidity of the water quality samples ranged between 3 and 9 NTU (nephelometric turbidity units). The Zone 3 water quality standards set the maximum 30-day average at 40 Jackson turbidity units (JTU) and the maximum instantaneous turbidity at 150 JTU. The turbidity in a given sample of water is expected to exhibit numerical values in JTU about twice the corresponding values in NTU (Pijanowski 1976). Nevertheless, the turbidity values measured at Fish House Cove are believed to be well within the applicable water quality standards. They indicate that water quality is high with respect to the transmissibility of light. These measurements

confirm the readily apparent visual clarity of the water (Figures 8 and 11).

Five Day Biochemical Oxygen Demand

The 5-day biochemical oxygen demand (BOD₅) values ranged from 1.6 to 3.6 mg/l (milligrams per liter). These BOD₅ values indicate the presence of oxygen-demanding substances that deplete the oxygen dissolved in the water column. There are no specific water quality standards for BOD₅. The Delaware River Basin Commission, however, allocates the allowable BOD loadings to effluent discharges.

Dissolved Oxygen

The concentration of oxygen dissolved in the water ranged from 0.4 to 4.0 mg/l. These levels are indicative of the depressed levels caused by oxygen-demanding substances. The consequence of these relatively low levels is stress on aquatic biota, particularly fish and other aquatic animals. The Delaware River Zone 3 water quality standards require that the 24-hour average concentration during early September be not less than 3.5 mg/l. This criterion was not satisfied at Fish House Cove in four of the six samples. The early September levels of dissolved oxygen were low enough to have caused severe stress to fish and other aquatic organisms, and to present a barrier to the passage of anadromous fish. The values are typical of the oxygen stress during the late summer which for many years has characterized the Delaware River in the vicinity of Philadelphia and Camden.

Orthophosphate

Orthophosphate is a measure of the total inorganic phosphate content of a water sample. Orthophosphate is an important nutrient to plants, and excessive concentrations can stimulate the nuisance growth of algae, given other favorable conditions. The measured values ranged from 0.14 to 0.20 mg/l (as phosphorus). These concentrations are in excess of the desired goal of 0.1 mg/l total phosphorus for the prevention of plant nuisances in streams and other flowing waters (USEPA 1976).

Oil and Grease

The total oil and grease concentrations ranged from 0.8 to 1.8 mg/l. These concentrations indicate that oil and grease are present, but do not indicate which of the thousands of organic compounds with varying physical, chemical, and toxicological properties are present in the water at Fish House Cove. These constituents may be volatile or non-volatile, soluble or insoluble, persistent or easily degraded. There are no quantitative stream standards for total oil and grease.

POINT SOURCES OF SELECTED POLLUTANTS

There are many major point sources of pollutants in the vicinity of Fish House Cove. The largest point source is the Philadelphia Northeast Water Pollution Control Plant on the Pennsylvania side of the River almost

Table 14. Results of analyses of surface water quality at three locations in Fish House Cove, Camden County, New Jersey, on 5 September 1979. Samples were collected one foot below the surface. All laboratory analyses were conducted by Standard Methods (APHA 1975). Station locations are shown in Figure 1.

STATION NUMBER	1		2		3	
Tide Stage	Low	High	Low	High	Low	High
Temperature ¹ (°Celsius)	26.5	27.5	26.5	26.5	26.0	26.5
Salinity (parts per thousand)	0.09	0.14	0.10	0.14	0.09	0.13
Conductivity ¹ (micromhos per cm)	345	440	370	440	345	430
Turbidity (nephelometric turbidity units)	3	5	4	4	9	3
pH	7.0	6.8	6.9	7.0	7.0	6.9
5 day biochemical oxygen demand (mg/l)	1.8	2.2	1.6	1.6	3.6	2.6
Dissolved oxygen (mg/l)	3.4	1.4	0.4	4.0	1.8	4.0
Orthophosphate (mg/l)	0.14	0.17	0.14	0.16	0.20	0.14
Oil and grease (mg/l)	1.0	1.8	1.8	1.1	0.8	1.1

¹Used to calculate salinity values.

opposite Fish House Cove (Figure 20). This municipal sewage treatment plant contributes organic wastes to Zone 3 and has a significant effect on water quality. The City of Philadelphia is currently taking steps to upgrade the level of pollutant removal efficiency at the plant.

There are 15 other point source discharges that affect water quality in the near vicinity of Fish House Cove (Table 15). The Pennsauken facility of Texaco discharges directly to the Cove, and a Camden municipal facility discharges less than 0.1 mile southwest of the Cove. The Camden facility is discharging effluent no better than primary at the present time, based on WAPORA field observations on 5 September 1979. Considerable foam was observed at the outfall. Because the Delaware River is tidal, discharges for substantial distances both upstream and downstream can be expected to affect the Cove ecosystem. The tidal volume is an order of magnitude greater than downstream flow, and organic chemicals are known to travel upstream in the Zone 3 of the River as far as 7 miles from River Mile 104 to River Mile 110 (Sheldon and Hites 1979).

Additional data were provided to the consultant concerning three NPDES permits by the Camden County Environmental Agency on 26 September 1979. The three permits are for the three oil storage and distribution facilities nearest Fish House Cove: Cities Service on Petty Island (NJ 0004511), Texaco on the northern border of the Cove (NJ 0005436), and Amerada Hess north of Texaco in Pennsauken (NJ 0004383). Amerada Hess has a single discharge point; the other facilities each have three discharge points. All three facilities discharge stormwater runoff following treatment by an oil-water separator. Texaco also discharges untreated boiler-blowdown water and (after treatment by the separator) truck-washing water.

The permit-mandated discharge water quality limitations vary among the three facilities. The Amerada Hess draft NPDES permit (for the period 1 August 1979 - 31 July 1984) specifies a daily maximum total oil and grease limit of 15 mg/l and pH between 6.0 and 9.0. The NJ-DEP, however, specified in its Section 401 (Clean Water Act) certification that the DRBC oil and grease limitation (10 mg/l) not be exceeded. The NJ-DEP Section 401 certification for the Cities Service permit dated 26 May 1974 set a maximum of 1.0 mg/l oil and grease at any time. An undated recent draft permit for Texaco specified the following effluent limitations:

OUTFALL	EFFLUENT	PARAMETER	DAILY MIN.	DAILY MAX.
1	Untreated boiler blowdown	Oil and grease	N/A	15 mg/l
		pH	6.0	11.2
		Temperature	N/A	≤93.4°C (200°F)
2	Stormwater runoff, after oil/water separation	Oil and grease	N/A	15 mg/l
		pH	6.0	9.0
3	Truck washings, after oil/water separation	Oil and grease	N/A	15 mg/l
		pH	6.0	9.0
		Total suspended solids	N/A	30 mg/l

Table 15. Principal point source discharges in the vicinity of Fish House Cove, Camden County, New Jersey (data from Camden County Environmental Agency, 1979). Because the Delaware River is tidal, both upstream and downstream discharges may affect Fish House Cove.

TYPE OF DISCHARGER	DISCHARGES DOWNSTREAM FROM FISH HOUSE COVE (BETWEEN RIVER MILES 100 AND 103)		DISCHARGES UPSTREAM FROM FISH HOUSE COVE (BETWEEN RIVER MILES 104 AND 106)	
	NAME	NPDES PERMIT NO.	NAME	NPDES PERMIT NO.
Municipal	NJ Water Co., Camden	NJ 0005215	Phila. Northeast Water Pollution Control Plant	PA 0026689
			Pennsauken Township Sewerage Authority	NJ 0025348
			Moorestown Township Sewage Treatment Plant	NJ 0024996
			Philadelphia Electric, Delaware Generating Sta.	--
Other Discharges	Cities Service, Pennsauken Terminal Allied Chemical, Camden	NJ 004511 --	Amerada Hess, Pennsauken	NJ 004383
			Texaco, Pennsauken Terminal	NJ 0005436
			Georgia-Pacific Corp.	NJ 0004669
			A.P. Green Refractories	PA 0011703
	National Sugar Refining Company	PA 0012645	U.S. Steel Products Division, Camden Plant	NJ 0005533
			Rohm and Haas, Philadelphia Plant	--

The NJDEP Section 401 certification for this permit (dated 4 June 1979) indicates that oil and grease concentrations are not to exceed 10 mg/l. NPDES regulations require random monthly monitoring of grab samples for oil and grease concentrations only.

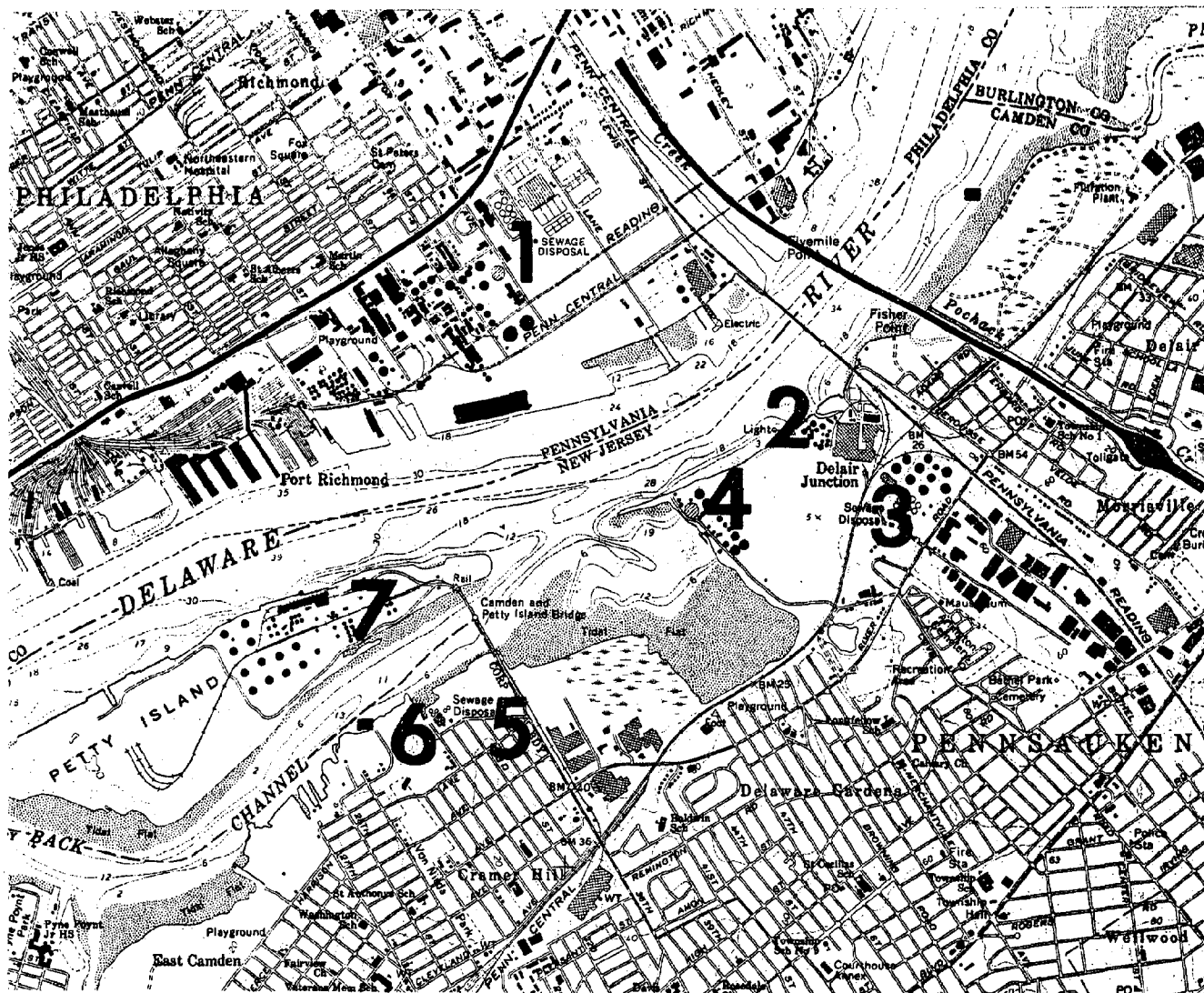
Monthly NPDES self-monitoring data as reported to USEPA were supplied to WAPORA by CCEA covering 50 months during the past 5 years at the Amerada Hess facility. These data indicate that, based on a single grab sample per month, the 10 mg/l oil and grease limit was exceeded on 23 occasions (46% of the time). The highest reported concentration in the effluent was 92.1 mg/l oil and grease during June 1976. Only one exceedance (13.62 mg/l during March) was reported during the first 6 months of 1979.

ASSESSMENT OF WATER QUALITY AND ENERGY RELATED FACILITIES

Water quality problems exist in the Delaware River because of the extensive agriculture, urban uses, landfills, and industry in the surrounding region. The shoreline uses in the vicinity of Fish House Cove are listed in Table 16 and depicted in Figure 19. On the basis of existing data, the principal water quality problem at Fish House Cove appears to be the depressed dissolved oxygen content of the waters, due chiefly to organic wastes. It is probable that the marsh vegetation and mudflats at the Cove contribute oxygen to the Cove waters.

The effluent discharges from the surrounding petroleum facilities, however, probably do not contribute significant amounts of oxygen-demanding substances. The oxygen-demanding substances detected in the samples from Fish House Cove (as measured by BOD) probably are contributed for the most part from other known sources such as the massive Philadelphia Northeast Sewage Treatment Plant and the nearby Camden and Pennsauken Treatment Plants. On the hypothesis that the nearby petroleum storage facilities are not contributing to the chief water quality problem at the Cove, the existing petroleum facilities may be considered not to be having a significant chronic adverse effect on water quality in the Cove at the present time. The principal known discharge from the petroleum storage facilities which are situated adjacent to the Cove is oil and grease found in stormwater runoff generated during and after rainfall events. The control of the oil and grease in the stormwater runoff is accomplished by an oil and water separator at each of the three petroleum distribution and storage facilities.

No data were collected on most of the regulated, potentially toxic parameters that could issue from oil storage or numerous other urban/industrial facilities or on industrial organic chemicals for the present report. The current NPDES permits do not regulate oil-contaminated ship and barge ballast water, which often has a high biological oxygen demand as well as substances deleterious to aquatic organisms. The untreated boiler blow-down water from the nearby petroleum facilities can contain corrosion inhibitors and algicides which can interfere with the metabolism of organisms which oxidize organic compounds. Chemicals added to boiler water to reduce corrosion, scale, and sludge include phosphate, sulfite, and sludge conditioners such as tannins, lignins, and starch organics.



LEGEND

- 1 Philadelphia Northeast Water Pollution Control Plant
- 2 Amerada Hess Oil Storage Facility
- 3 Pennsauken Sewage Treatment Plant
- 4 Texaco Oil Storage Facility
- 5 New Jersey Water Company
- 6 Camden Sewage Treatment Plant
- 7 Cities Service Oil Storage Facility

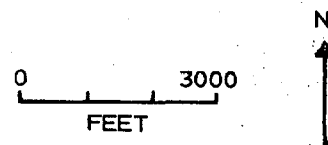


Figure 20. Facilities with point-source discharges of wastewater in the vicinity of Fish House Cove, Delaware River, Camden County, New Jersey. Base map is from USGS (1973).

Table 16. Generalized characteristics of the banks of the Delaware River in the vicinity of Fish House Cove (Tyranski 1979).

Mile 94 to Mile 102	Naval Base and City of Philadelphia; piers and bulkheads; mostly high ground. City of Camden; mostly bulkheaded, about one third filled ground, remainder high; piers and industry.
Mile 102 to Mile 108	City of Philadelphia, piers and bulkheads; high ground; industry. About half bulkheaded; much high ground, some fills; Petty Island, east of main channel, mostly bulkheaded fill; industry.

Oil and grease were found in measurable concentrations in the water at Fish House Cove, although obvious deleterious effects were not observed. It is not known, due to the limited water quality sampling program, what the oil and grease concentrations might be during a rainfall event when storm-water discharges are being added both locally at Fish House Cove and to the Delaware River generally throughout the region or what effects may emanate from the Cove sediment.

Given the legally allowed oil and grease concentrations in the effluent discharges from the three nearby facilities, compared to the volume of water in Fish House Cove or the Delaware River, the net increase in the receiving water is likely to be negligible. For example, using the appropriate conversion factors, the combined oil and grease effluent discharge from the three discharge points from Texaco (NJ 0005436) to Fish House Cove would be on the order of one pound per day. This estimated increase of oil and grease is based on the following information and assumptions:

- (1) The oil and grease discharge is 10 mg/l (the daily maximum limit allowed).
- (2) The average discharge, as per the NPDES permit (NJ0005436), is 8,700 gpd.
- (3) The quantity of oil and grease discharged using the assumed concentration and the discharge rate was calculated from the following formula

$$\text{Discharge in } \frac{\text{pounds}}{\text{day}} = 8.34 \cdot C \cdot R = 0.73 \frac{\text{pounds}}{\text{day}}$$

where C = concentration in mg/l (10)
R = rate in mgd (0.0087)

- (4) The tidal surface area of Fish House Cove was measured by planimetry to be 196.1 acres (Table 2). The average depth was conservatively estimated to be 5.6 feet. On this basis the volume of water in Fish House Cove was estimated as 23.3 million cubic feet. (The average depth of 82.1 acres of open water was assumed to be 12 feet, and the average depth of 114.0 acres of marsh, mudflat, and beach was assumed to be 1 foot.)
- (5) The net increase in oil and grease in Fish House Cove from the daily discharge is estimated to be as follows:

$$\frac{\text{pounds/day pollutant}}{62.5 \times \text{volume of receiving water (million cubic feet)}} = \frac{0.00024 \text{ mg/l/day}}{\text{concentration}}$$

The increase in concentration of 0.00024 mg/l oil and grease per day is a very small amount. The actual

increase may be smaller, because neither the flushing action in Fish House Cove, the rate at which oil and grease moves between the water column and the substrate, nor the degradation or evaporation rate of the oil and grease fraction have been considered in this simplified estimate.

The amount of oil and grease pollutants that have been incorporated into the sediments is unknown. Such pollutants may have an adverse effect because their bacterial degradation rate is slow. No attempt was made to study the benthos of the Cove, for such work was beyond the scope of this report.

MITIGATING MEASURES

Based on this limited review and brief water quality study, the need for mitigating measures for reducing the chronic effects of legal discharges of oil and grease from existing energy-related facilities has not been clearly established. The predominant water quality problem in Fish House Cove and adjacent sections of the Delaware River appears to be the result of discharges from facilities other than those related to energy adjacent to Fish House Cove. The potential catastrophic effects of oil spilled by vessels or from land-based facilities adjacent to the waterway were not addressed in detail here. WAPORA personnel recollect a spill of aviation fuel into the unnamed creek adjacent to the Camden Wastewater Treatment Plant just downstream from Fish House Cove during 1975. The cleanup effort lasted two days at that time. Hence a potential for spills close to Fish House Cove definitely exists.

The potentially catastrophic effects of oil spilled by vessels or from land-based facilities adjacent to the Cove could be mitigated by requiring the three petroleum facilities to develop a joint emergency oil spill contingency control plan and to join the Delaware River Cooperative, a coalition of Delaware River industries formed to minimize the impacts of oil spills on the river from Philadelphia to the Delaware Memorial Bridge. When the current NPDES permits issued to these petroleum facilities come up for their five-year renewals, strict abatement measures should be incorporated as a condition for renewal to comply with the Clean Water Act, which calls for the elimination of all discharges of pollutants into the waters of the United States by 1985. Potential impacts and mitigative measures are summarized in Table 17.

Table 17. Potential Impacts on Fish House Cove.

SOURCE	POTENTIAL IMPACT	GENERIC MITIGATION MEASURES
<u>Energy Facilities</u>		
Catastrophic spills of oil or process chemicals in river	Acute damage to vegetation, fish, and wildlife from oil or chemicals in water and sediment	Prevention, containment, clean up of spills; oil spill emergency plans required by USEPA, prepared and executed cooperatively; participation in Delaware River Cooperative
Chronic discharge of oil and other pollutants from point source outfalls	Stress to vegetation, fish, and wildlife from oil and other pollutants in water and sediment; increased temperature, stress on fish	Treatment of point source effluent; self-monitoring of pollutant concentrations in discharge as per NPDES; strict enforcement of violations and maximum concentration by USEPA; elimination of direct discharge of boiler blowdown water into River; abatement program to reduce volume of discharge; eventual elimination to maximum extent feasible of all discharges as a condition for future NPDES permit renewals; treatment of stormwater; maximum roofing of oil facility areas to prevent runoff from contacting pavements and flushing oil; separate conveyance of roof runoff to River
Dredging of new or maintained channels for access near Cove or for pipelines crossing Delaware River	Sedimentation stress to annual plants, benthos, and fish; salinity increase from increased flushing of channel	Limitation of dredging to least damaging season and to slack tide; containment of turbidity using screens whenever practicable

Table 17. Potential Impacts on Fish House Cove (continued).

SOURCE	POTENTIAL IMPACT	GENERIC MITIGATION MEASURES
<u>Energy Facilities</u>		
Increased tanker and barge traffic causing discharge of ballast and bilge containing contaminants	Stress to fish, wildlife, vegetation from additional discharge	Removal and treatment of toxic substances in bilge and ballast. Recovery of oil from ballast with return to refinery for processing.
Associated paved surfaces runoff	Stress to vegetation, fish, and wildlife from unregulated, non-point runoff	Porous pavement, buffer strip regulation or settling ponds to reduce sediment and associated pollutants reaching Delaware River
Encroachment by fill	Destruction of vegetation and of wildlife habitat	Extension of marsh into land currently upland elsewhere; restoration and enhancement of conditions for scarce plants; thorough public review of required state and federal permits
Diversion of freshwater flow for consumptive uses	Increased salinity	None
<u>Other Sources</u>		
Catastrophic spills from non-energy related sources	Same as for energy-related facilities	Same as for energy-related facilities
Chronic discharges from point sources	Same as for energy-related facilities	Same as for energy-related facilities
Dredging	Same as for energy-related facilities	Same as for energy-related facilities
Non-point runoff	Same as for energy-related facilities	Same as for energy-related facilities

Table 17. Potential Impacts on Fish House Cove (concluded).

SOURCE	POTENTIAL IMPACT	GENERIC MITIGATION MEASURES
<u>Other Sources</u>		
Encroachment and filling for solid waste disposal or other uses	Stress from reduced dissolved oxygen concentrations, increased nuisance algae growth from nutrients and sedimentation.	Upgrading of treatment to minimize oxygen demand and nutrient load in effluent.
Increased rail traffic	Stress from increased noise levels and activity on waterfowl and other birds	None
Excavation of right-of-way for proposed interceptor lines	Sedimentation resulting in stress on vegetation, fish, wildlife	Use of effective erosion control measures during and after excavation.
Placement of demolition debris for "Land Reclamation" project adjacent to Cove	Stress to vegetation, fish, wildlife from sedimentation	Constant surveillance by responsible officials to insure compliance with erosion control plan.

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Figure 6. . Louisiana heron (*Egretta tricolor*) on mudflats at Fish House Cove, Delaware River, Camden County, 13 September 1979. Slender arrowhead is the vegetation. More than twenty herons were observed at Fish House Cove during field collection on 5 September 1979.



Figure 7. Typical appearance of the upper mixed marsh at Fish House Cove, Delaware River, Camden County, 13 September 1979. Species in the photograph include narrowleaf cattail, river bulrush, spiked loosestrife, arrowheads, broadleaf cattail, and halberdleaf tearthumb.



Figure 8. Spiked loosestrife in the upper marsh at Fish House Cove, Delaware River, Camden County, 13 September 1979. To the right is common arrowhead.



Figure 9. Lodged and matted wild rice at Fish House Cove, Delaware River, Camden County, New Jersey, 13 September 1979. Scattered clumps of arrowhead are visible in the matrix of wild rice. In the distance is a stand of willow lowland forest.



Figure 10. Common arrowhead in middle mixed marsh, Fish House Cove, Delaware River, Camden County, 13 September 1979.



Figure 11. Middle mixed tidal marsh at Fish House Cove, Delaware River, Camden County, 13 September 1979. Pickerelweed, water smartweed, and water hemp are prominent in this photograph.



Figure 12. Bur marigold in the middle mixed marsh, Fish House Cove, Delaware River, Camden County, 13 September 1979.



Figure 13. Arrow-arum in the upper mixed marsh, Fish House Cove, Delaware River, Camden County, 13 September 1979.



Figure 14. Submerged Aquatics (common elodea and naiad) in the lower mixed marsh at Fish House Cove, Delaware River, Camden County, New Jersey, September 1979. The transparency of the water is readily apparent in the photograph.



Figure 15. Slender arrowhead at Fish House Cove, Delaware River, Camden County, New Jersey, September 1979. This form of arrowhead also is not known elsewhere in Camden County.



Figure 16. Bur arrowhead at Fish House Cove, Delaware River Camden County, New Jersey, September 1979. This is a component of the lower mixed marsh which is not known elsewhere in Camden County.



Figure 17. Common threesquare at Fish House Cove, Delaware River, Camden County, New Jersey, September 1979.



Figure 18. Spatterdock stand at Fish House Cove, Delaware River, Camden County, New Jersey, 13 September 1979.

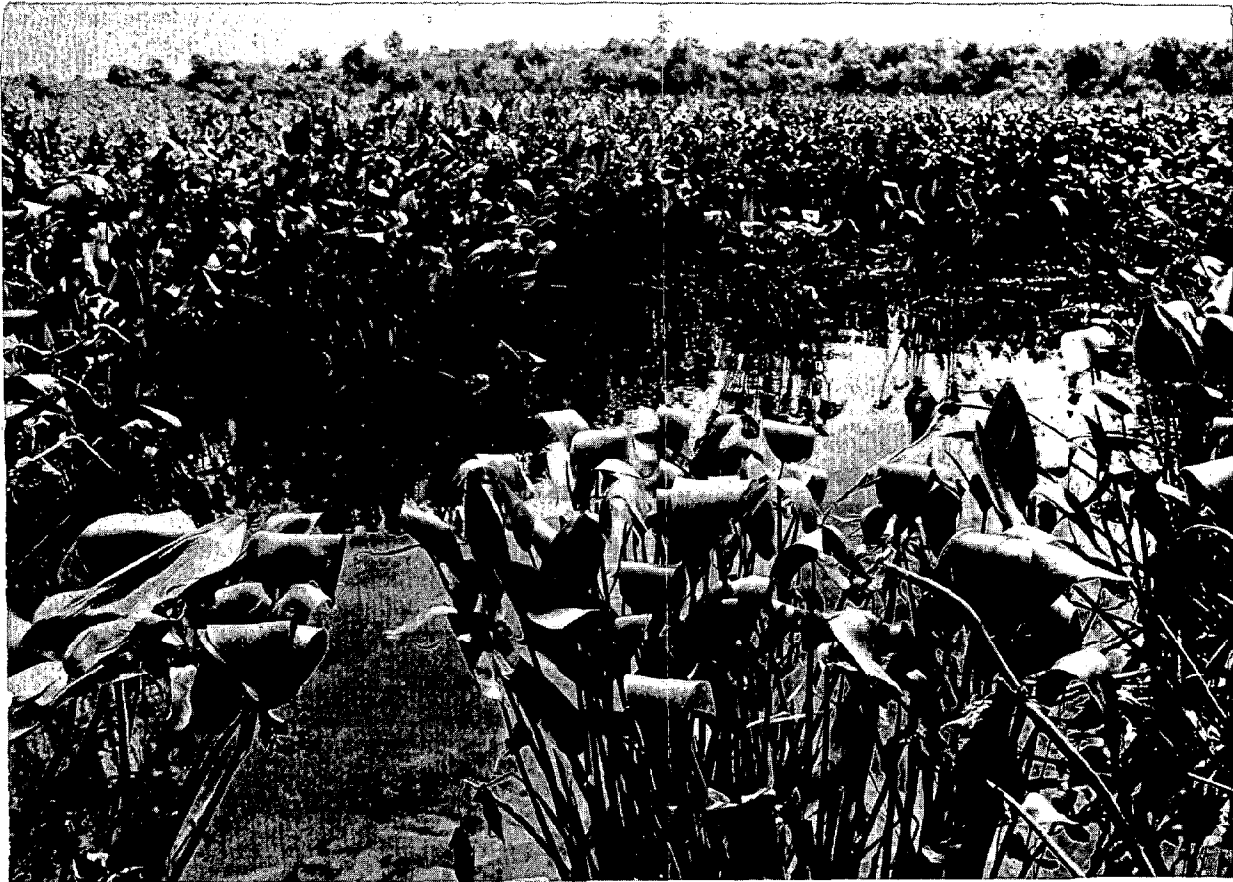


Figure 19. Prominent pickerelweed in the lower mixed marsh at Fish House Cove, Delaware River, Camden County, New Jersey, September 1979. Submerged aquatics are visible in the clear water as the dark patches left of center.

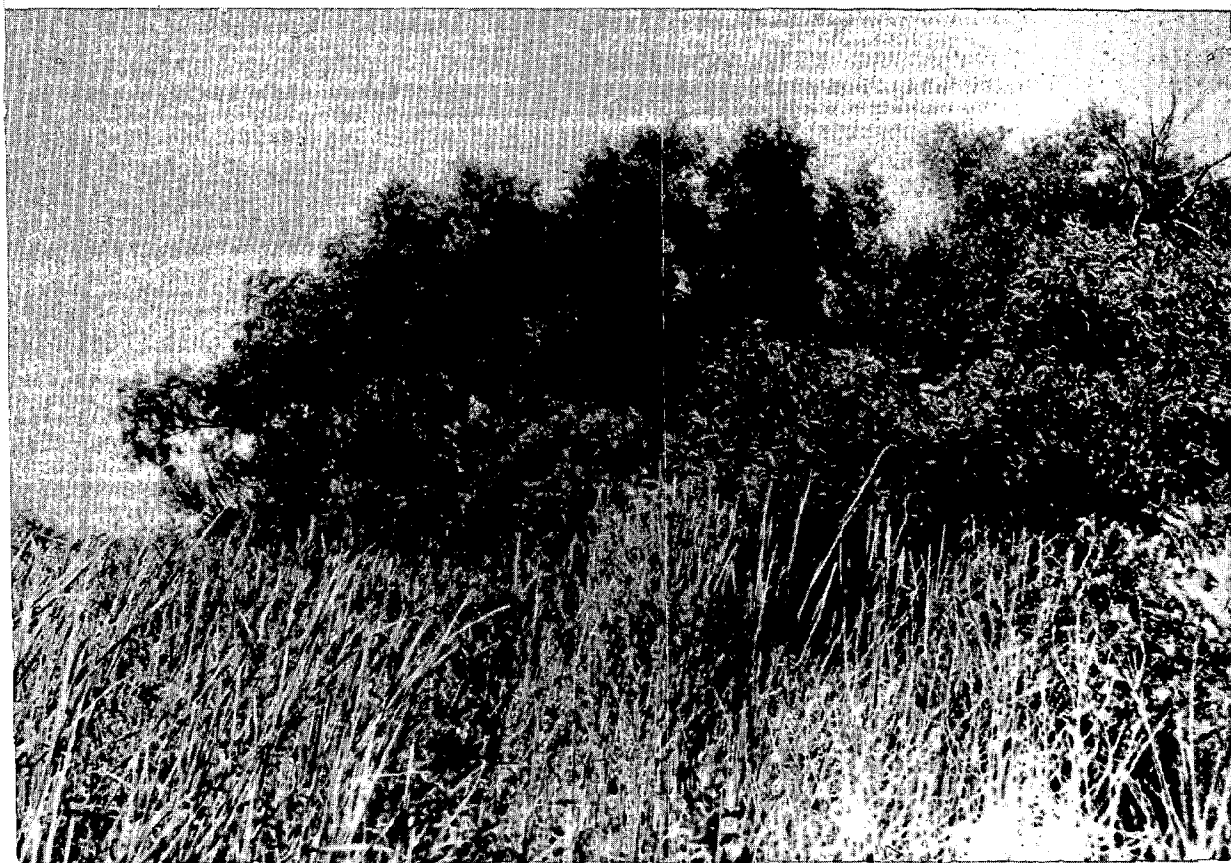


Figure 20. Narrowleaf cattail at Fish House Cove, Delaware River, Camden County, New Jersey, September 1979. The wetland forest in the background consists primarily of black willow.



Figure 21. Common reed stand at Fish House Cove, Delaware River, Camden County, New Jersey, September 1979.



Figure 22. The industrial waterfront of Philadelphia (background) opposite Fish House Cove (foreground). Delaware River, Camden County, 13 September 1979.



Figure 23. Wild rice at Fish House Cove, Delaware River, Camden County, New Jersey, 13 September 1979. Common arrowhead leaves are visible in the foreground.

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